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A GREAT CORN PRODUCTS PLANT AT ROBY, IND.

ELECTRICALLY OPERATED WITH CAPACITY TO HANDLE 30,000 BU. OF CORN DAILY

BY C. A. TUPPER

FROM American maize, or corn, as it is commonly called in this country, a greater variety of marketable commodities are made than the average person would even suspect, and among the most valuable of such products are those of the great glucose factories. To the capital financing these plants, which are very expensive to construct, and to the engineers responsible for their design, credit should be given for true pioneer work—work in the interest of all the people, producers and consumers alike; for it has added immeasurably to the wealth and available resources of the country.

FIG. 1. PLANT OF THE AMERICAN MAIZE PRODUCTS CO.

Owing to their enormous first cost, only a very few such plants have been constructed, the latest notable addition to them being that of the American Maize Products Company at Roby, Indiana, a suburb of Chicago. Some idea of the large area which it covers and the number of separate buildings required for the various processes may be gained from the general photographic view accompanying this article; but it is only when one traverses structure after structure and floor after floor devoted to the manufacture of corn syrups, jellies, glucose, grape sugar, starch and numerous varieties of special feedstuffs that any adequate conception of the immensity of the works is possible. Furthermore it is seen to what an extent electric drive has been introduced and how important is the part it plays in economical operation, as indicated briefly by the following description.

Process of Manufacture

The corn, which in all cases forms the raw material, is brought in on cars, weighed, elevated, cleaned, weighed again and then sent to enormous storage tanks, whence it is taken as needed.

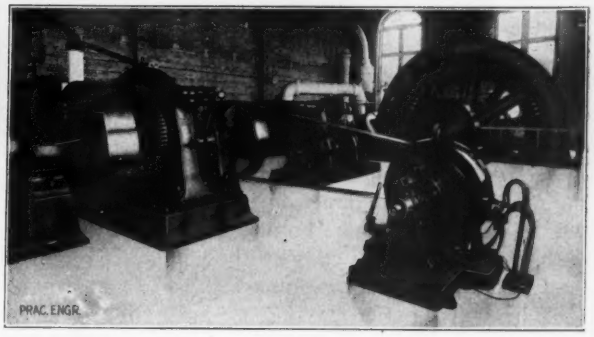

FIG. 2. ENGINE ROOM WITH LARGE UNIT IN BACKGROUND

First of the manufacturing processes is that which takes place in the steep house. The tanks here hold about 2000 bu. each, and the steeping mixture is sulphurous acid, in which the corn is kept for 30 to 40 hr. at a temperature of 100 to 115 deg.

The acid water is then drawn off and the corn conveyed to machines known as "degerminators," built

by the Foos Manufacturing Company, where it is crushed sufficiently to free the germ, then pumped to the germ separators, where the germ is floated off. This germ is used for one of the most valuable of the byproducts. The crushed corn, being removed from the bottom of the separators, at one end, is then run over shaking sieves to remove the free starch.

The bulk of the mass, however, tails over the end of the sieves into a supply tank, whence it is fed into buhr stone mills. There it is ground very fine. The product of these mills is then pumped into troughs and fed onto shaking silk-covered sieves, where streams of water play on the mass, washing the starch out through the sieves and leaving the ground hulls to pass over the end and into feed mixing tanks.

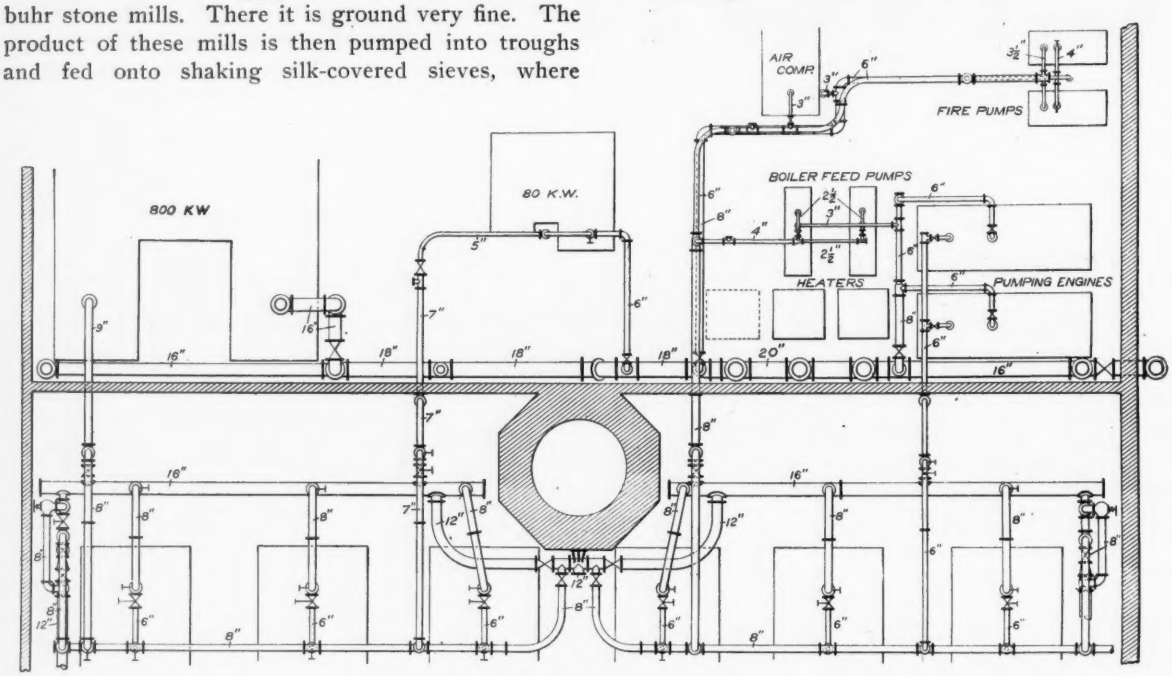

FIG. 3. PLAN OF STEAM PIPING

The starch removed in the two processes above described, and all surplus of starch obtained from various other processes, is then collected in a tank and pumped to the settling basins, where the starch is continuously concentrated. Here the surplus water passes off at the top and the starch settles to the bottom, whence it is pumped into pipes feeding shaking sieves covered with fine bolting silk, where the particles of meal that still cling to the starch are removed and sent back to be reground.

The starch, after passing through the sieves, is about the consistency of cream and is pumped to table feed tanks on the top floor of the building, thence fed onto starch tables; each table is about 2 ft. wide and 110 ft. long; here the starch settles on the bottom and the gluten and water and a great many of the impurities float off and go to the gluten concentrating tanks, where the gluten is freed from most of the water and pumped to feed mixing tanks.

When a set of starch tables has been run a sufficient length of time for an accumulation of about 6 in. of starch at the head, or feeding end, tapering to nothing on the other end, it is then of about the consistency of wet clay. In this state it is shoveled onto belt conveyers and conveyed to breaker tanks. There water is added, the starch thoroughly washed, pumped into table-feeding tanks and retabled, the water passing over the end mixing with water and gluten of the first tabling. The starch is now ready to be made into glucose, sugar or dry starch.

During all of the processes thus far described, power is applied, wherever needed, by means of alternating current motors of the induction type, built by the Allis-Chalmers Company, of Milwaukee. Most of these are of standard construction, but the motors connected to the buhr mills are special machines, having been developed for this specific purpose.

Each is of the vertical belted type designed for operation on 60 cycles, and has a normal rated output of 75 h. p. The stator core is supported in a cast-iron housing provided with projecting lugs that rest on the slide rails. The stator core shows open slots that allow the coils to be readily removed in case repairs are necessary. The stator has a 14-pole winding, thus giving a synchronous speed of 514 r. p. m., the full load speed being approximately 490 r. p. m.

The rotor spider is mounted on a vertical shaft which passes through a guide bearing at the top of the motor. A second guide bearing is placed at the bottom, and the weight of the rotating part is carried by a multiple disk, self aligning, thrust bearing under the lower end of the shaft. A complete oiling system is provided, whereby oil is supplied to the upper bearing from a large sight-feed oil cup and, after passing

through this bearing, flows to the lower one. The thrust bearing is designed so that all parts are thoroughly lubricated. The pulley is at the top of the motor, and the vertical arrangement allows the motor to be belted directly to the mill without the use of a quarter turn belt.

In addition to the buhr mills the elevators, conveyers, shaking sieves and, in fact, all of the moving machinery referred to are driven by motors of capacities ranging from 5 to 30 h. p. Some of the larger sizes are, however, required in the later processes, as will be mentioned in the proper place.

Glucose and Sugar

If the starch is to be made into glucose or sugar, it is shoveled from the tables onto belt conveyers and conveyed to breaker tanks, where fresh water is added until the starch is made into a liquid having about the consistency of cream. Then it is pumped into the starch tanks in the refinery, and from there discharged into copper converters. In these converters it is mixed with hydrochloric acid and subjected for about 10 min. to 40 lb. steam pressure. Then it is blown to neutralizers, where soda ash is added to neutralize the acid, and allowed to run through canvas lined filter presses, which remove the coarse impurities.

Further filtering then takes place through tanks filled with bone black; and, as the liquid issues from these, it is pumped to feeding tanks and passed into evaporators, where some of the water is evaporated and the specific gravity of the liquor raised from 15 deg. Baume to about 30 deg. Baume. It is then pumped from these continuous evaporators, which are triple effects, to filter feeding tanks, where it is again allowed to filter through bone black and then pumped to pan feeding tanks, drawn into finishing vacuum pan and concentrated to 42, 43, 44 or 45 deg. Baume, as may be desired. When the batch is finished, a valve on the bottom of each pan is opened and it flows by gravity to the coolers.

If glucose, it is now ready for the barrels, tank cars or syrup departments; if sugar, for the barrels or to be sent to the crystallizing pans if it is to be shipped.

Syrup

If the glucose is to be made into syrup, it passes to the syrup mixing tanks, where a certain percentage of glucose, cane syrup and flavoring extracts are thoroughly mixed by air agitation. The resulting syrup then goes to the can filling machines on the floor below, where it is put up in air tight, friction-top tin cans, packed in boxes and loaded on cars for shipment.

Dry Starch

To return to the section immediately preceding that headed "Glucose and Sugar": If the product from the corn is to be made into starch, it is shoveled from the tables onto belt conveyers and conveyed to the Starch Drying House, where it is placed on trays covered with burlap, put into steel rack cars and run into drying tunnels, each of which will hold 11 cars.

When a car at the "hot" end is removed, another on the wet or "cold" end takes its place, 12 to 15 hr. being required for a car to pass from one end to the other, so as to thoroughly dry the starch.

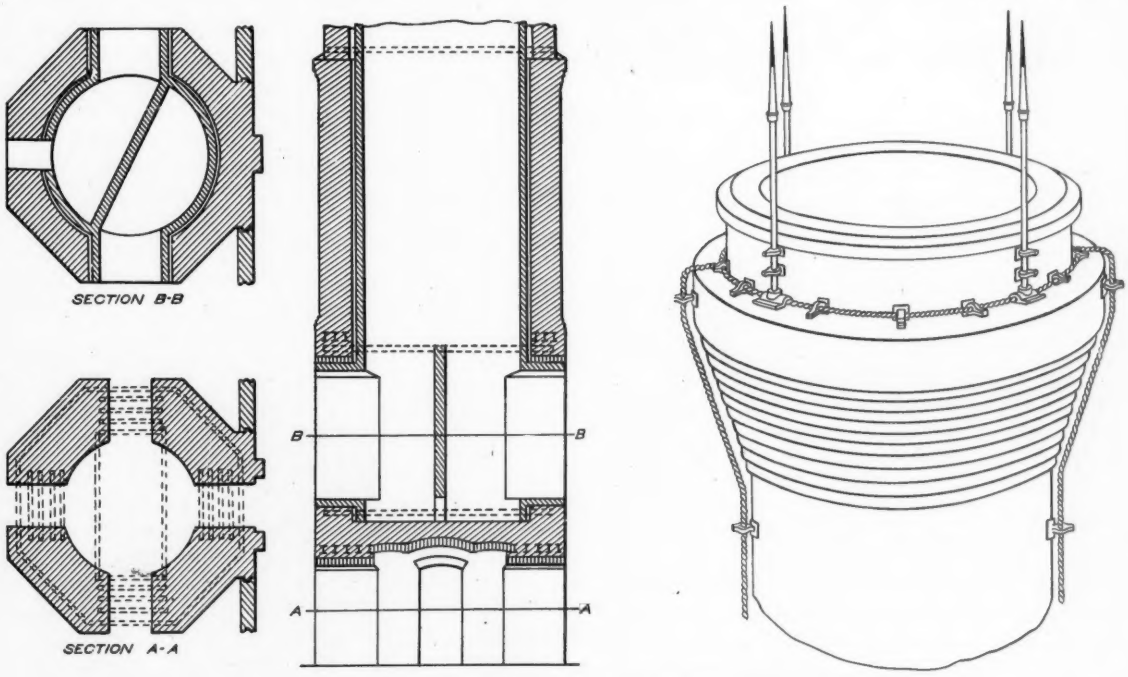

FIG. 4. BASE OF STACK AND SYSTEM OF LIGHTNING PROTECTION

On the hot end of the tunnel there is an iron grating, covering underground ducts connected with large fans, each fan being 12 to 14 ft. high and driven by a steam engine direct-connected. Each fan has in connection with it, steam coils composed of about 25,000 ft. of 1 in. pipe, through which the air from out-of-

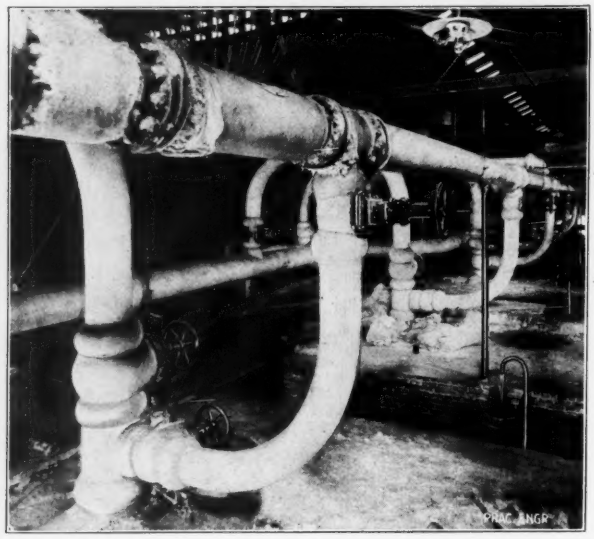

FIG. 5. STEAM HEADERS AND CONNECTION TO BOILERS

doors is drawn and heated to about 180 deg. F. and blown through the tunnels. One fan usually supplies heat to about 10 tunnels.

When the cars are removed from the tunnels they pass on to a transfer truck, also running on rails, and are brought to rails running parallel to the tunnels, where the starch on the trays is dumped into hoppers which feed the starch into elevators. By these it is raised to the third story and conveyed to the Grinding and Storage Building, where the dried starch passes through grinding mills and reels and sifters covered with silk bolting cloth and from there to bins and packers. With the exception of the fans all of the apparatus mentioned is motor driven.

Thorough Separating and Cleaning Processes

It will have been observed by a careful reader, from the description thus far given, how completely the various separating and cleansing processes are carried out, thereby insuring, in each instance, a purity of product which cannot fail to increase very largely the consumption of corn syrup and related commodities as their qualities become more generally understood. To bring about this result, without the use of harmful chemicals, which are quicker in their action, requires a long line of expensive machinery, and the management of the American Maize Products Co. is to be particularly commended for installing only the best; for anything less means an inferior product.

Byproducts

Of almost equal importance to the commodities mentioned above are the byproducts of the various processes, viz: gluten-feed, corn-oil, oil cake and fertilizer mixture.

Gluten Feed

The gluten feed is composed of the ground hulls that tail over the silk sieves and go to feed mixing tanks, where the gluten from the tables also finds its way. In these tanks it is thoroughly agitated and then pumped through large canvas lined filter presses. When a press is full, it is opened and one plate after the other is dumped into screw conveyors under the presses and conveyed to the feed dryers. The feed then contains about 60 per cent moisture.

The dryers are large revolving cylinders, with a number of boiler flues, running longitudinally, in which there is steam. The feed is on the outside of these flues and, in coming in contact with the hot surfaces, the water is driven out and the air passing through the dryers carries the moisture off through ventilating stacks.

The dryers installed at the plant are the largest type of what are known as regular "Rotary Steam Dryers" built by the Louisville Drying Machinery Co., and their construction is sufficiently interesting to be briefly described, as follows:

The feed to be dried, brought from the filter presses in the room adjoining, is transmitted to the dryers by an elevator and conveyor, being fed from the floor immediately above the machines and through spouts to the hoppers of the machines. In the bottom of the hoppers there are conveyors for carrying the feed into the dryers. These dryers being set slightly on an incline, the feed gradually advances through the machines by gravity, taking from 20 to 30 min. in the process.

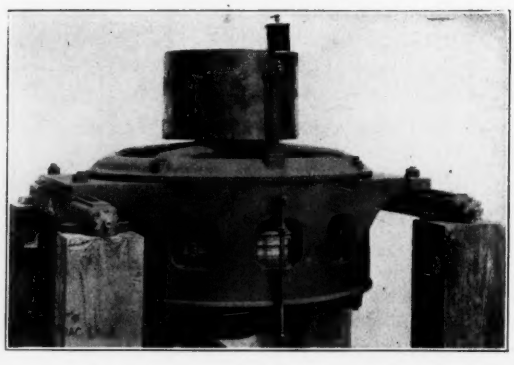

FIG. 6. ONE OF THE VERTICAL INDUCTION MOTORS USED IN PLANT

Charcoal iron boiler tubes run the entire length of the cylinder, which is 25 ft. long. The tubes are expanded at each end into manifolds and back of the tubes and between the tubes and the shell is a hard wood lining which prevents radiation and protects the iron from the acids contained in the feed; back of each separate tube is a flight. These tubes and flights

form pockets for carrying up the meal while in process of drying.

The condensation in the tubes is carried out and through a stuffing box to a trap which discharges the water back to the boiler heater at almost boiling temperature. The tubes and manifolds are kept absolutely free from the condensed water, which is a very important feature, as it gives the material to be dried the full benefit of the temperature of the live steam at 60 lb. pressure.

The turning apparatus, propelled by shafting from a 40 h. p. Allis-Chalmers motor, through gearing giving three reductions, gives them an exceedingly easy drive, rotating the cylinder on heavy bearing tires and double trunnions with an expenditure of not to exceed 5 or 6 h. p. to a machine.

When the feed leaves the dry end of the dryers, it is conveyed to a fan, which blows it to the Feed Grinding House. Here the feed is thoroughly ground and put through reels covered with very fine wire screens, and only feed of a uniform fineness is allowed to pass from the reels to the storage bins, where it is ready for shipment. The coarse tailings from the reels go back to the mills to be reground. The grinding is done by No. 19 Foos Attrition Mills, each mill belted direct to two 40 h. p. motors.

Corn Oil

Corn oil is obtained from the germ which is floated off at one end of the separators, passed over shaking sieves, and sprinkled with water to detach the particles of starch adhering to it (which are conveyed by a separate channel to the rest of the starch), the germs tailing over sieves to a conveyor feeding expeller built by the V. D. Anderson Co., Cleveland, where the water is squeezed out. This material, then containing about 60 per cent moisture, next goes to the germ dryers, which are similar to those used for drying the gluten feed. Here the germ is dried down to about 4 per cent moisture and elevated to a cleaner, where all foreign matter is eliminated, the clean germ going to Allis-Chalmers roller mills, driven by motors of the same company's manufacture, and thence to a steam jacketed conveyor, which conveys it to Anderson oil expellers, where the oil is squeezed out. It then flows to a tank and is pumped through a filter press, where all meal, etc., is removed. The filtered oil flows to settling tanks in the oil storage and shipping house and is then ready for the barrels or tank cars.

The Anderson oil expellers, of which four have been installed in this plant, are continuous in operation, and not only press the germs continuously, but also perform this work without the use of press cloths or mats. They are driven by a 40 h. p. motor.

The tempering apparatus is to take the place of the old fashioned heater, and also works on a continuous principle. The mode of operation, as above indicated, is to first grind the germs, after which they are fed continuously into the tempering apparatus, and from thence into the expeller, where the oil is pressed or extracted from the germ meal.

This machine is not only very economical in operation from the fact that one man can take care of an entire battery, but it also has twice the capacity of the hydraulic press, and produces a superior grade of oil due to the fact that it extracts the oil at a lower temperature than that required to obtain it by the hydraulic process.

Oil Cake

The residue leaving the Anderson oil expellers is known as corn oil cake and is conveyed to a Foos grinding mill, where it undergoes the same process as in grinding feed, then to the cake bins and sacks and is ready for shipment.

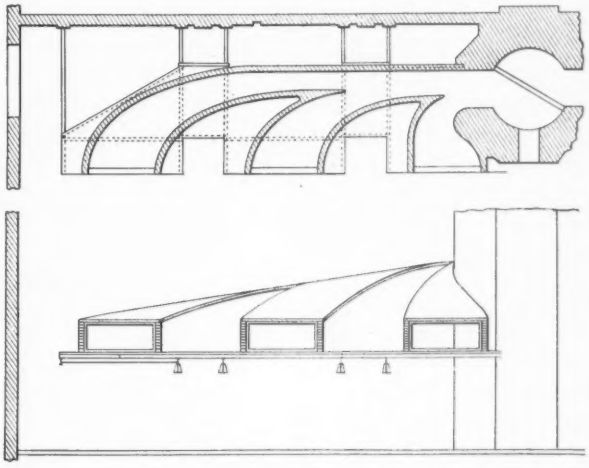

FIG. 7. ARRANGEMENT OF BREECHING TO PROVIDE FOR EQUAL DRAFT

Fertilizer Mixer

The pores of the bone black in the filters used for the syrup process become filled with impurities after several hours' use, and it is then thoroughly washed and steamed and removed through a manhole at the bottom; thence elevated and discharged into dryers, where the material is dried by the waste gases from the kilns below. The bone black passes from the dryers through retorts in kilns and then through cooler pipes, automatically discharging onto a belt conveyor, where it is conveyed to a bucket elevator and elevated to a cleaner. There all dust and impurities are removed (this material being sold for fertilizer purposes) and the bone black is discharged into a storage tank and again to the filters, new bone black being added to take the place of the dust, etc., that is removed by the cleaner. The kilns are fired with producer gas supplied by Morgan gas producers.

Pumping Machinery

Not the least important part of this great plant is the pumping machinery, which consists of the following units supplied by the Platt Iron Works, of Dayton, Ohio.

Two 12 and 18 by 14 by 18 duplex pumping engines of the outside center packed plunger type, each having a capacity of 1400 gal. of water per minute. Three single-stage centrifugal pumps for the steeps, each having a capacity of 200 gal. per minute. These pumps are placed on extended bases and direct connected to 7½ h. p. motors. The shaft coming in contact with the liquor, was made of bronze composition. One single-stage centrifugal pump for the shakers, having a capacity of 400 gal. per minute. This is direct connected to a 15 h. p. motor.

steam cylinders and piston packed water boxes for operating under a liquid pressure of 50 lb. with an available steam pressure of 130 lb.

Six 8 and 6 by 10 in. duplex yoke type pumps for the refinery. Two 12 and 8 by 12 in. duplex outside center packed plunger boiler feed pumps, equipped with chilled iron plungers, brass covered plunger rods and brass bushed plunger glands and boxes.

Two 10 and 16 by 10 in. duplex crank and flywheel vacuum pumps, provided with automatic governors.

One 10 and 10 by 12 in. duplex clapper valve pump,

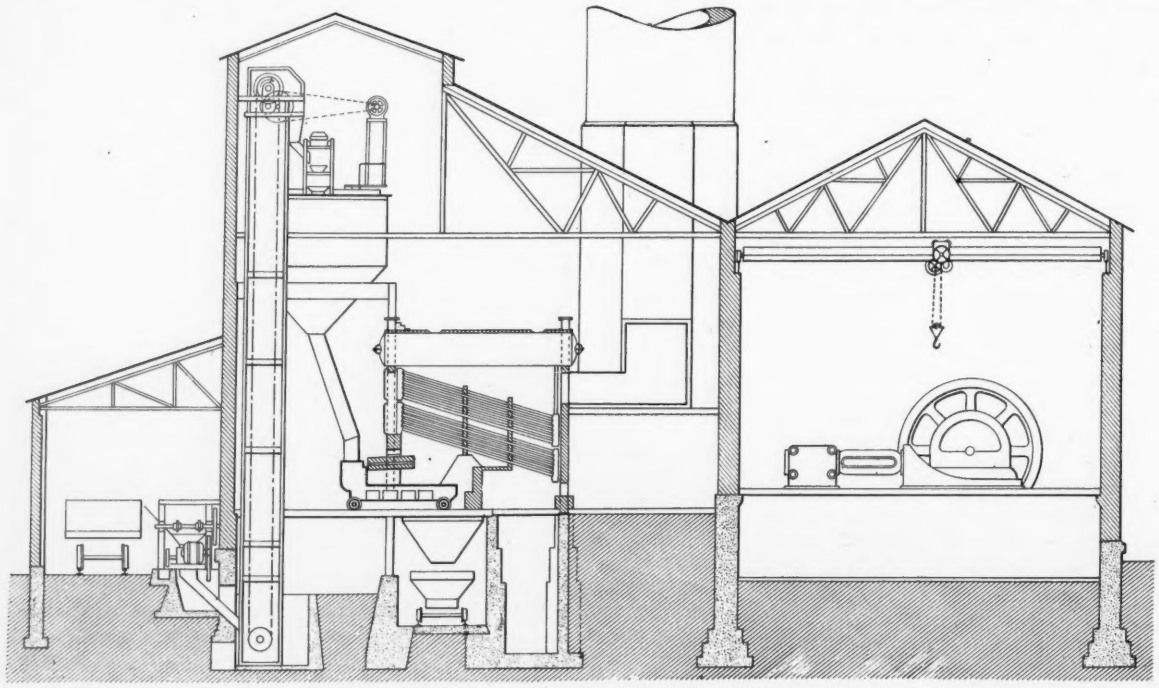

FIG. 8. SECTION THROUGH BOILER AND ENGINE ROOMS

One single-stage centrifugal pump for discharging slop from the buhr mills, having a capacity of 400 gal. per minute. The pump is placed on an extended base and direct connected to a 17½ h. p. motor. Four single-stage centrifugal pumps for crushed corn, each direct connected to a 15 h. p. motor. One single-stage centrifugal pump for the starch breaker, having a capacity of 400 gal. per minute, direct connected to a 15 h. p. motor. One single-stage centrifugal pump for water, having a capacity of 700 gal. per minute, direct connected to a 22 h. p. motor.

The centrifugal pumps are of the balanced type, with single suction opening. The casing is circular and concentric, fitted with discharge flange, and with feet for bolting to foundation. The suction is on the drawing side, and admits the water to that side of the casing. It passes through cores in the chute case to the front end of the impeller, so that the impeller has suction on each side and is consequently balanced.

Two 8 and 8 by 10 in. duplex pumps and two 10 and 10 by 10 in. duplex pumps, with plain slide valve with slide valve steam end, and brass fitted clapper valve liquid end.

Power House

The power plant of this establishment has been designed in strict accordance with latest practice and possesses many features of special merit. In the engine room there is but one large main unit, which is a 26 and 44 by 48 in. Allis-Chalmers cross-compound Corliss engine, connected to an alternator of the same company's build and having a normal rating of 800 k. w. The generator is a 3-phase 60-cycle machine of the revolving field type and was designed to deliver 480 v. pressure at a speed of 90 r. p. m. The rotor of the generator is about 17 ft. in diameter and weighs 17 tons. The load carried by this machine is mostly power, consisting of 150 motors of various types and ranging in capacity from 5 to 75 h. p. There is, of course, a sufficient number of incandescents to light the plant. The lights are carried on 3-phase feeders and as nearly as possible are distributed equally between the phases. From 4 to 6 hr.

a day the large unit is run on 25 per cent overload and apparently carries it with the greatest of ease.

Besides the large unit there is a smaller direct connected set consisting of a 14 by 14 in. Chandler & Taylor engine and a 3-phase Allis-Chalmers revolving

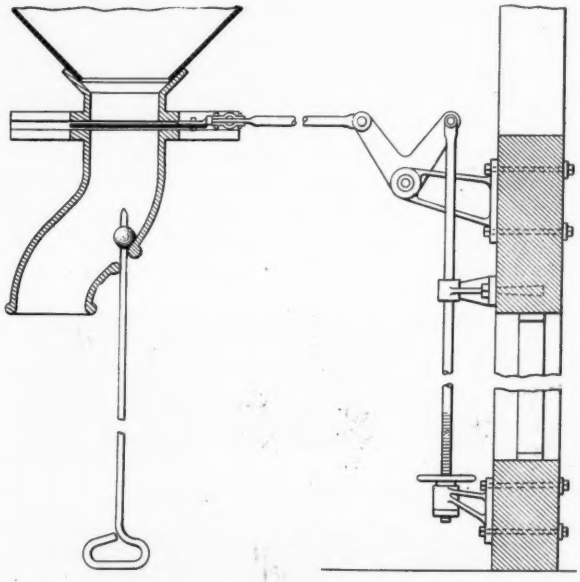

FIG. 9. SCHEME FOR OPENING GATE TO COAL HOPPER

field generator. To this set is also belted a 35-k. w. direct-current exciter. The small set is used only at night or at any time when there is a very small load to carry. When starting up the larger unit it is also used for exciting current, the 3-phase alternating current being transformed to direct current by means of a 50-k. w. motor-generator set. The belted exciter may also be used, so that there are at least two sources of excitation. When the large machine is running exciting current is obtained from the motor-generator set, the synchronous motor receiving current from the main generating unit.

For control of the electrical apparatus and distribution of the load the station has a 7-panel switchboard, which was installed by Kohler Bros., of Chicago. The board is equipped with a full line of instruments, consisting of ammeters and voltmeters of Wagner make, Westinghouse integrating and recording wattmeters, a Westinghouse synchroscope and a power factor indicator. Condit 3-pole circuit breakers are installed and Cutler-Hammer chain-operated field rheostats.

In the same room but at a lower level than the power plant floor are some of the pumps previously mentioned, that is, the two pumping engines for water supply, the two boiler feed pumps and the two Underwriter fire pumps. In addition to the pumps are two Stilwell feed water heaters with space for a third, and also an air compressor to furnish the shop with a supply of compressed air for pneumatic tools, etc.

Boiler Room

On account of the large demand for steam throughout the plant there are six Aultman & Taylor boilers installed, each rated at 440 h. p., set singly and each having 4,403 sq. ft. of heating surface. The boilers carry a pressure of 150 lb. per sq. in., and five of them are in constant operation, with one down for cleaning or repairs. They are equipped with chain grate stokers of the Mansfield type and are run with natural draft supplied by a radial brick stack built by the Heine Chimney Co., of Chicago. The stack is 200 ft. high from the boiler room floor, which is 6 ft. above grade, 10 ft. in diameter all the way up and has a radial brick lining for 60 ft. of its height. It is located right in the boiler room midway between the two middle boilers and has a flue opening on either side with a 6 in. baffle wall in the middle to prevent interference of draft. For a brick stack the location is unusual, and a peculiar feature is the passageways under the stack. These are at right angles to each other and are on a level with the boiler room floor. The construction to provide for these passageways is shown in one of the accompanying illustrations, and in another view the method of protecting the chimney from lightning. A cable is drawn around the top of the chimney and is provided with four points, each having a 12 in. platinum tip. Two ground connections are provided and the cables are secured to the chimney by means of bronze anchor fastenings.

Special care was taken in the design of the breech-

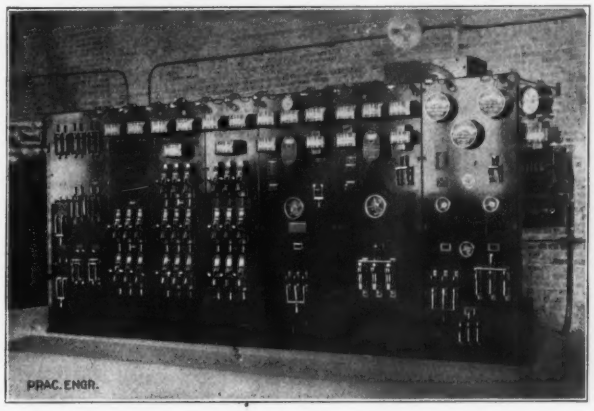

FIG. 10. SEVEN PANEL BLACK ENAMEL SWITCHBOARD

ing, which was built up of brick and covered with reinforced concrete. As above indicated, there are three boilers on each side of the stack, so that there are three boilers discharging their gases into each breeching. On this account the area at entrance to the stack was made equal to three times the area of the outlet from the boiler, twice as large between the second and third boilers and at the first boiler of the same size as the outlet. This arrangement gives each boiler an equal draft and prevents any choking of the gases in its passage to the stack.

Feed water for the boilers is taken from Wolf Lake, which is only a few feet from the plant. The water in this small lake is unusually muddy and it was necessary to install a filtration plant for its purification. The National Filter Co., of Chicago, erected the plant.

For the supply of the entire works the water is drawn from the filtration plant through a 12 in. pipe by one of the pumping engines previously mentioned. To this main supply a 4 in. tap is made for boiler feed, and before reaching the boilers the water is passed through the Stilwell feed water heaters, which are 12 ft. 9 in. high and 66 in. in diameter. The heaters raise the water to a temperature of 200 deg. F. But little cold water is required, however, as the condensation from traps and exhaust is usually sufficient.

arranged as in the drawing, it is possible to utilize either header and cut out, if necessary, either half of the main header for repairs. From one to the full number of boilers can be turned onto the headers as desired, and there is no danger of any pumping back and forth between the boilers from unequal pressures, as each leader is equipped with an automatic stop valve.

Live steam is used to some extent in the plant, especially for the fan engines, steam dryers and pumps, in connection with the drying rooms. The connection to the main header for this purpose is shown at the left of the drawing. Most of the steam, however, used for the various processes is exhaust from the engine units and the pumps. For this reason condensers were not installed. This supply of exhaust steam is collected in a large 18 and 20 in. pipe shown in the drawing, and at infrequent intervals when the steam is not all required in the plant, it is exhausted to atmosphere.

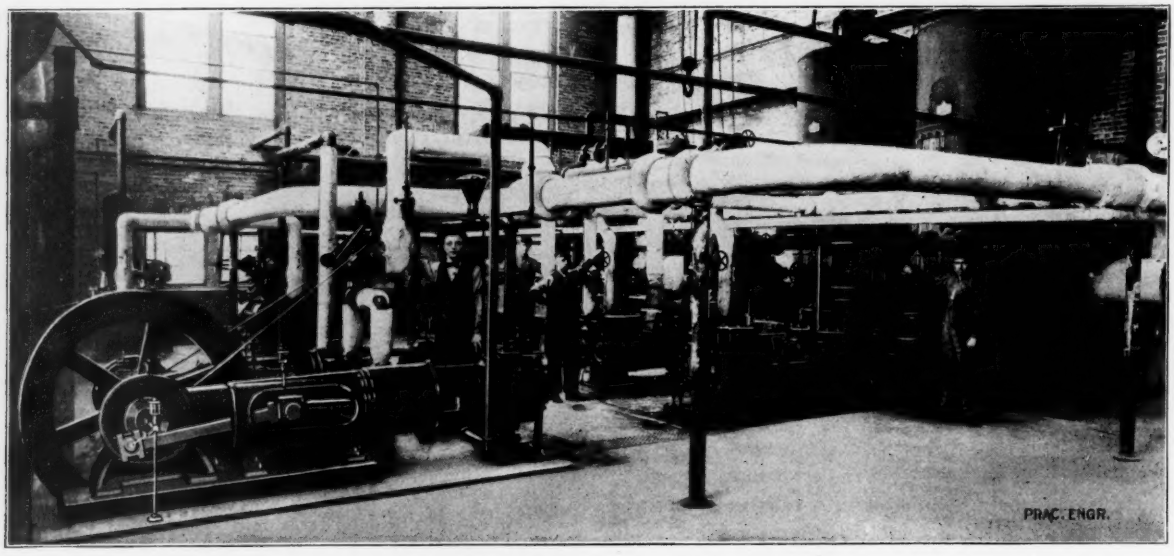

FIG. II. PUMPING MACHINERY IN POWER PLANT

To collect the ashes, each boiler is provided with an ash hopper, from which the ashes are taken in small dump cars. These cars are pulled mechanically outside of the building and the ashes are dumped on the premises and used for filling purposes.

As the coal used in the stokers contains considerable dust after passing through the crushing machine, there is a good deal of fine material which will drop through the chain grates, and in a great many cases is entirely wasted. In the plant under description, however, each hopper is provided with a plate to divert the fine coal dropping through in this manner. Provision is now being made to convey this fine coal to the elevator and eventually return it to the stokers.

Steam Piping

This is clearly shown in one of the accompanying illustrations and will need no extended description. It will be noted that two headers have been provided: the main header, which is 16 in. in diameter, and an auxiliary header 8 in. in diameter. With the piping

Coal Handling Facilities

Of the entire boiler room, the feature of chief interest is undoubtedly the coal handling apparatus. This is unusually complete for a plant employing only six boilers.

A receiving conveyor has been placed parallel with the track on which the coal arrives, being between the track and the wall of the boiler house. The conveyor is provided with a hinged shoveling apron placed at an angle of about 60 deg. between it and the side of the car. To this apron the coal is shoveled and flows down on the conveyor, and is carried forward and discharged to a standard boiler house crusher, operated by a 30 h. p. Allis-Chalmers motor, by which mine-run size is reduced to 1½ in. maximum cubes.

The hopper that receives the crushed coal is con-

nected by a chute to a continuous bucket elevator which raises the coal and transfers it to a flight conveyor extending through the boiler house over bunkers. It is then delivered by the conveyor through gates placed in the trough to such bunkers as it may be desired to fill.

When handling mine-run, the capacity of the installation is governed by the maximum capacity of the crusher, which is from 40 to 50 tons per hour. When handling fine coal, not requiring crushing, the capacity is controlled by the elevator, namely from 50 to 60 tons per hour. The system is electrically driven throughout with controlling mechanism, located inside the boiler house. It was installed by the Link Belt Co., of Chicago.

In an installation of this kind with the coal hoppers above the boilers and feeding the coal through chutes to the stoker, difficulty is always experienced in opening or closing the gates controlling the supply of coal, as they are very apt to wedge or become stuck in some way. To prevent this and get a straight pull or push on the gate, a bell crank and screw arrangement was provided. This is shown in Fig. 9. The screw has only 6 threads to the inch, so that a few turns of the wheel will open or close the gate.

Another feature of interest is the poke rod shown in the same illustration. This is provided with a ball which will close the opening through which it passes and at the same time allow a thrust in any direction to start the coal if it happens to become lodged at the mouth of the hopper.

Buildings

The power house, corn storage tanks and manufacturing buildings are of fireproof construction; and the warehouses are of mill construction. All buildings are so arranged as to have excellent light and ventilation and the floors of the fireproof buildings are arranged to be flushed with water, at the close of each day, so as to have them at all times in a state of cleanliness and perfect sanitary condition. A complete sprinkler system is installed, and with a 50,000 gal. water tower in connection with the two fire pumps a pressure of 200 lb. is maintained all over the grounds.

Capacity

This plant, which was planned and constructed under the supervision of its superintendent, P. L. Saenger, assisted by G. C. Welch, S. H. Lanyon and J. J. Waechter, is designed to handle 30,000 bu. of corn daily, the machinery for one-half of which has already been installed. In completeness and economical operation it leaves practically nothing to be desired; and the large demand for corn starch and syrups, now existing throughout the country, insures a good market both for its products and those of the company's predecessors in this particular field.

A TALK WITH A CHIEF ENGINEER

BOILER CALCULATIONS AND BOILER SETTINGS

By Wm. Kavanagh

IN the last talk the chief gave such interesting and useful information on the steam boiler and riveted seams that both myself and Kingsly decided to ask him to explain various important formulas relating to the structure of the boiler and other useful pointers necessary for an engineer to know when he appears before the examining board to obtain a license. When Kingsly and myself entered the chief's engine room we found the chief in a very pleasant mood and inclined to give information freely on any subject that might be brought up during the talk. The chief having requested his visitors to be seated, began his talk as follows:

Bursting and Safe Working Pressure

"In my last talk I showed you how to find the load that would rupture a boiler and also how you could find the safe working pressure. You will notice there are four factors to be considered when discovering either the bursting or safe working pressures, namely, the thickness of the iron, the tensile strength of the boiler plate, the diameter of the boiler shell, and the percentage allowed for riveting, or as it is called the percentage of riveted seam. If any three of the above four factors are given, the other factor can be found. Thus, the thickness of the metal or its tensile strength, the style of riveting to be employed can be determined, also the diameter, and, of course, the safe working and bursting pressures. The formula for the purpose of discovering any of these quantities is written and reads as follows:

$$\frac{T \times f \times p}{5 \times R} = \text{S. W. P.}$$

"If the thickness of the metal T be multiplied by its tensile strength f and this product be multiplied by the percentage of riveted seam p, and the complete product be divided by five times the radius R of the boiler, the quotient will equal the safe working pressure S. W. P.

"If it is wished to take out of this formula any quantity, all that is necessary to do is to follow the law relating to long division."

At this point the chief asked Kingsly to find the safe working pressure of a boiler having the following dimensions: thickness of shell, ½ in.; tensile strength of metal, 55,000 lb.; percentage of riveted seam, 0.8; and radius of shell, 30 in.

Kingsly worked out the problem as follows:

$$\frac{\frac{1}{2} \times 55{,}000 \times 0.8}{5 \times 30} = 146.6 \text{ lb.}$$

which is the S. W. P. of the boiler. The chief said that this pressure was correct, and then asked Kingsly what pressure could be carried on this boiler if the radius was halved? Kingsly answered by saying, "the pressure could be doubled," and added, "if the diameter was doubled only one-half or 73 lb. could be carried."

"Now, Kingsly," said the chief, "I want you to tell me what pressure will rupture this boiler and why you used five times the radius as a divisor in finding the S. W. P. of the boiler." Kingsly replied that 733

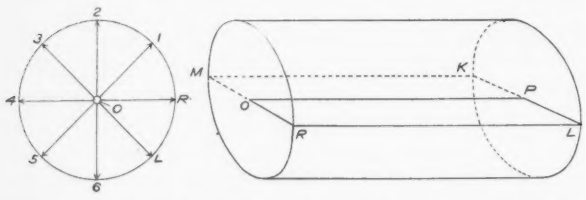

FIG. 1. SKETCH ILLUSTRATING RADIUS AND DIAMETER OF BOILER

pounds would burst the boiler and figured it out as follows:

$$\frac{55{,}000 \times \frac{1}{2} \times 0.8}{30} = 733 \text{ lb.},$$

which equals the bursting pressure.

Here Kingsly said he did not understand why the radius or half the diameter of the boiler was used as a divisor, but Kingsly understood that the figure 5 was used as a factor of safety, at the same time asking the chief to explain why the radius was used as a divisor in some engineer's books while the diameter was used in others. In answer to Kingsly's question the chief drew a sketch similar to the first in Fig. 1, and continued, "You know, Kingsly, when the radius is used as a divisor, we are only considering the thickness of one side of the boiler shell, and when the diameter is used in the divisor, we then must take into consideration twice the thickness of the shell. In considering the radius O R as a divisor, we suppose O R to hinge at O and, of course, O R will have any number of positions as O 1, O 2, etc., and the area of the parallelogram having O R for one of its sides and its length equal to the length of the boiler will equal O R times the length of the boiler."

Here the chief drew the second sketch in Fig. 1, inscribed the parallelogram O R L P as shown, and continued: "If you consider the parallelogram to have one of its sides equal to the boiler diameter and its length equal to the length of the boiler, the area of this parallelogram will be double the area of O R L P, as shown by the letters M O R L P K; therefore, you will use the diameter in the divisor, while you will use the radius as a divisor when the parallelogram O R L P only is considered.

"Thus, let us consider the boiler whose working pressure you have just found, and let us find the S. W. P. and bursting pressure of this boiler by using the diameter in the divisor instead of the radius. We have:

$$\frac{55{,}000 \times 1 \times 0.8}{5 \times 60} = 146.6$$

which equals the S. W. P. Now let us find the bursting pressure. We have:

$$\frac{55{,}000 \times 1 \times 0.8}{60} = 733$$

and this equals the bursting pressure.

"So you see we shall arrive at the same result whether we use the radius or diameter. You should memorize one of these formulas before you appear at the examining board, and, of course, the easiest way to remember the formula is to bear in mind the shape of the formula, the letters which compose the formula, their value and the operations to be performed on them. It is poor policy to try and memorize two different formulas on the same subject.

Setting for Tubular Boiler

"You will need also to be able to draw or sketch a horizontal tubular boiler and the mode of setting it. Let me make you a sketch of this." Here the chief drew the sketch shown in Fig. 2, and continued: "A drawing like this will enable you to pass an examination for the highest grade of license, but you must be able to answer some questions about the mode of setting as well as about the construction of the boiler.

"When subjected to heat the boiler tends to

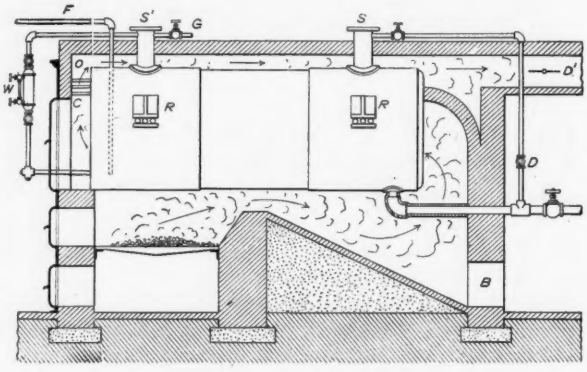

FIG. 2. SETTING FOR TUBULAR BOILER

lengthen and also increase its diameter, and for this reason the lugs of the boiler are placed on rollers as shown at R, and the rollers rest on plates which are placed on the walls. These rollers allow the lengthening or shortening of the boiler with the least amount of friction. Should the boiler be built rigidly in the walls, it increases the liability of leakage and shortening of the life of the boiler as well as cracked and leaky walls.

"When a boiler is properly set it not only rests on rollers or other means to permit expansion and contraction, but is also inclined towards the rear, or in other words, when the boiler is set, it is higher in the front than the back, and the object in doing this is to

insure sufficient water over the tubes in the back when the water is low in the front. If you incline the boiler towards the front and the water should fall to or below the first gage, then in all probability there would be no water over the upper row of tubes in the back. Hence for this reason it is good practise to pitch or incline the boiler towards the back. The amount of pitch to give the boiler is not a fixed quantity; some engineers want their boilers to pitch 1-16 in. per foot, while others prefer to double this pitch, or ⅛ in. to the foot.

"I have indicated the gage cocks at C, and you will need to know what height the first gage cock is above the first or highest row of tubes. This distance is generally from 3 to 4 in., but it varies with different boilermakers. Notice how the blowdown is connected and how it is protected from the heat by asbestos covering. When a circulating pipe is connected in the blowdown, a circulation is set up which prevents the pipe from becoming filled with scale. When no means for circulation is attached to the blowdown pipe, it fills with mud and scale, which induces the rapid destruction of this pipe. For this reason a circulating pipe connected like that shown at D is connected to the blowdown and the valve D is always open during operation of the boiler. Of course, when a blowdown is fitted in this way it is not necessary to protect the pipe further.

"The feed pipe is shown at F, and in this case you will notice it is connected on top of the boiler and extends on the inside downward to within 1 ft. of the fire sheet. When the feed pipe is connected in this or a similar way, it prevents cracking of the fire sheet, which is inevitable when the feed water is fed into the boiler along the fire sheet.

"Connections for the water column are shown at W and for the safety valve and main steam pipe at S and S^1, respectively. The steam gage connection is shown at G, the damper at D^1, and the direction of the draft is shown by the arrows. You will notice in this style of setting the heated gases are carried over the shell and a door for permitting the cleaning out of this or upper flue is shown at O. The door for the cleaning out of the back connection is shown at B.

"Let me tell you now, Kingsly, you will need to be very particular about this drawing. Don't forget any connection, and try and make your sketch in proportion, as the examiners will judge your ability very largely from your drawing."

ESTIMATING PIPING MATERIAL FOR A LARGE PLANT.

By W. G. Glover

THE following plans show a modern, high class power plant equipment, on which it is necessary to submit bids for connecting up all the various apparatus. The first consideration must be the pressure, and the degrees of superheat, if any, carried. We will suppose the boiler will deliver steam at 175 lb. pressure and 200 deg. superheat. This will be a total temperature of 577.31 deg., as the temperature of 175 lb. steam = 377.31 deg.

Pipes and Fittings for High Superheat

For this high temperature it is necessary to provide a first class installation. The expansion strains are excessive, and the fittings and valves must be carefully considered. In the case of the fittings, these must be of extra heavy cast steel,—the faces of the flanges must have a perfect bearing for gaskets, for which purpose it is good practice to provide a small raised face, 1/16 or 1/32 in. high, from inside the bolt holes to the inside of the opening of the fitting, and this raised face should have a smooth tool finish, which will allow of no cutting of the gasket when the flanges are brought together. The flanges should be finished on the back about the bolt holes to allow of a perfect base for the heads or nuts of the bolts.

All valves should also be made of cast steel, with seat rings in the bodies and on the bearing faces of the wedges, or gates, made of nickel steel, brass being entirely unfit for this high temperature and pressure,—and with valve stems of nickel steel, which should contain approximately 25 per cent of nickel. All valve joints to be packed with soft steel gaskets or double copper gaskets with asbestos centers, the flanges to be finished the same as for the fittings, 1/16 in. raised face with smooth tool finish and bolt holes spot faced.

The pipe should be made of extra heavy thickness, and the bends of standard thickness. This is to allow for free expansion, which the bends will readily take care of. Flanges on the pipes should be of forged steel welded on, which makes an ideal joint, the flanges being solid with the pipe. A second choice would be forged or cast steel flanges with the ends of the pipe drawn over the outside of the flanges to the inner sides of the bolt holes, and then the face given a smooth tool finish. This allows the flanges to swivel on the pipes and allows of slight variations without the necessity of special drilling.

Some engineers advocate ground joints in place of gaskets. This consists of finishing the faces of the flanges with the 1/16-in. raised face and smooth tool finish and, then grinding the faces of the flanges together with emery and oil when placed in position on the work. In the writer's opinion such practise is a mistake, as it makes the lines too rigid, it costs more than gaskets, and the joints do not remain tight.

All joints should be provided with wrought-iron bolts and cold pressed hexagon nuts. The gaskets should be made of soft steel, or of pressed fiber, 1/16 in. thick, or of copper-jacketed asbestos gaskets, a number of very satisfactory gaskets being on the market for this purpose.

Requirements when Steam is not Superheated

If the boiler pressure be 175 lb., steam with superheat, the fittings should be made of semisteel, or ferrosteel, the valves extra heavy wedge gates, with outside screw and yokes, and with pipe of standard (or full weight) thickness, and bends of the same material.

The flanges may be of semisteel, screwed on the pipes, or made with the ends of the pipe drawn over the faces of the flanges to the inside of the bolt holes, and then refaced with smooth tool finish. All flanges should have 1/16 in. raised face, and all bolt holes should be "spot faced."

zontally and vertically, as in Fig. 2, radius of bends 5' 0", with 8—10"x17.5" outside diameter flanges made on and refaced and drilled.

4—10" regular weight 90° bends, 6' 6"x6' 6" centers to face, 5' 0" radius, 8—10"x17.5" extra heavy flanges made on and refaced, and drilled. These bends, being of regular thickness of pipe, will take care of all expansion strains in this section of piping.

We next count the joints, so that the bolts and gaskets may be allowed for, and find 8—6" and 16—10" extra heavy joints. This means that eight 6-in.

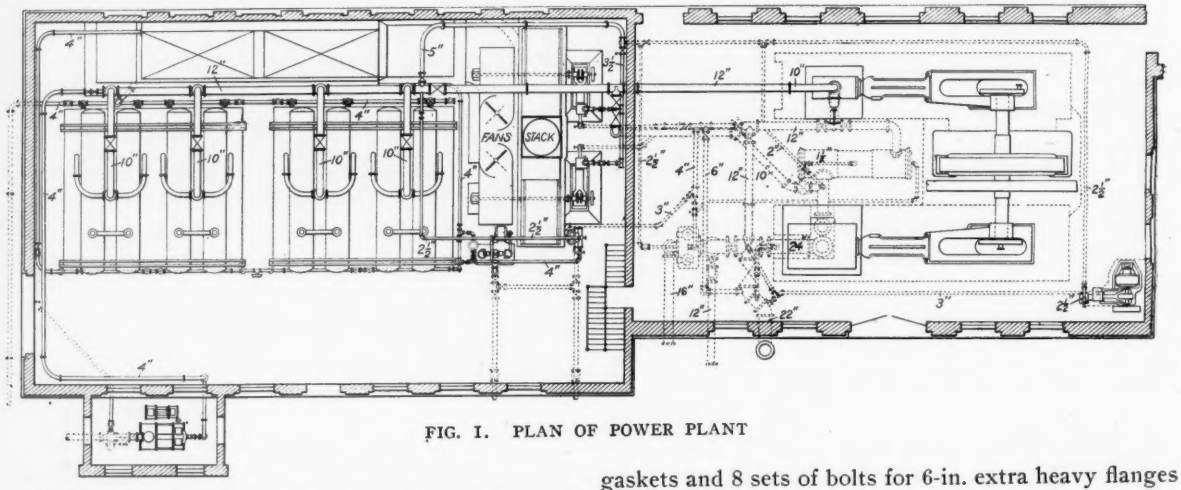

FIG. 1. PLAN OF POWER PLANT

Gaskets may be of corrugated copper, two for each joint, or a high quality rubber cut to fit inside the bolt hole, and to have a smooth bearing on the raised faces of the flanges.

Listing Steam Connections

Starting from the boiler connections, we list all material to the main header, then to the high-pressure engine, to the low-pressure engine, to auxiliaries, to pumps, and to fire pumps. These lists should then show valves, fittings, pipe, pipe bends, flanges, separators, bolts and gaskets, with miscellaneous material, the different items being listed in sets to facilitate pricing as follows:

Steam Header

Commencing at boiler flanges, the steam lines start with 6-in. nonreturn stop valves, so placed as to instantly arrest the flow of steam in case a tube in the boiler collapses, or any part of the boiler gives way, preventing the steam from entering the particular boiler from other boilers. If any repairs are necessary in the boiler, this valve will prevent steam entering while the workmen are making repairs. If the valves are provided with indicators on their sides, they act as a check on the fireman by showing whether the valves are open and the boilers are doing their full share of work.

4—6"x6"x10" Ex. heavy tees, faced and drilled.

4—10" regular weight 90° bends, 12' 6"x6' 6" centers of bend to face of flanges, measured hori-

gaskets and 8 sets of bolts for 6-in. extra heavy flanges and 16—10" gaskets and 16 sets of bolts for 10" extra heavy flanges are required.

Line to High-Pressure Engine

The next line to be taken may be from the main header to the high-pressure engine, and shows material as follows:

5—12"x12"x10" extra heavy tees, faced and drilled.

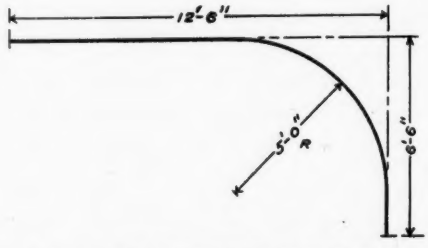

FIG. 2. DETAIL SKETCH OF PIPE BEND

1—12"x12"x5" ditto, with 2½" bottom outlet screwed (cross).

1—10" vertical high-pressure steam separator, faced and drilled.

This is an arrangement whereby the wet steam from the boilers, carrying more or less entrained water, is made to strike against corrugated plates, causing the steam to be freed from the water and to pass on to the engine practically dry, the water drops down to a receiver, which is relieved by trapping the hot water back to the heater.

7 pieces of 12″ extra heavy pipe, 86′ 0″ total length.
Threads 14—12″ (threads are generally charged for at a price above the cost of the pipe).
14—12″x20″ extra heavy flanges, faced and drilled.

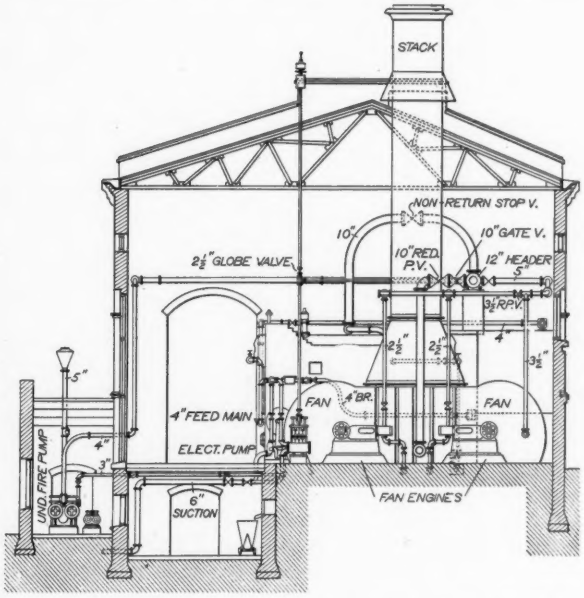

FIG. 3. ELEVATION OF PLANT THROUGH BOILER ROOM

Labor making on and refacing extra heavy flanges 14—12″.
1—10″ std. weight 90° bend, 6′ 6″x6′ 6″ ctrs. to face 5′ 0″ radius, with 2—10″x17.5″ outside diameter flanges, faced and drilled.
1—12″ high-pressure outside screw and yoke gate valve, faced and drilled.

An outside screw valve is so made that the stem rises when the valve is opened and lowers when it is shut, affording a perfect indicator to tell whether the valve is open or shut.

Bolts and corrugated copper gaskets for 15—12″ and 2—10″ extra heavy joints.

Steam Line to Low-Pressure Engine

The next line may be the steam to low-pressure engine from main header, as follows:
1—10″ high-pressure outside screw and yoke gate valve, faced and drilled.
1—10″ pressure reducing valve, faced and drilled.

This is to reduce the high pressure steam down to the pressure adapted to the low-pressure engine, and may be regulated at will,—a number of very good regulating valves for this purpose are on the market.
1—10″ std. pressure outside screw and yoke gate valve, faced and drilled, fitted with an extension stem 4′ 0″ long.
1—10″ finished indicator floor stand, for above 10″ outside screw gate valve.

This is to allow the valve to be operated from engine room floor, the indicator attached to the side of the floor stand will indicate the area the valve is open, ¼ open, ½ open, ¾ open, or full open, also the number of inches the disk of the valve is raised off its seat, 1″, 2″, 3″, etc., to 10″.
2—10″ std. flanged elbows, faced and drilled.
2—10″ ditto 45°.
6—10″x16″ outside diameter flanges faced and drilled.
3—pcs. 10″ pipe, 35′ 0″ total.
Threads, 6—10″.
Labor making on and refacing 6—10″ standard flanges.
Bolts and corrugated copper gaskets for 9—10″ std. joints.
Bolts and corrugated copper gaskets for 2—10″ high-pressure joints.

Steam Line to Fire Pump

1—4″ extra heavy outside screw and yoke gate valve, faced and drilled.
1—4″ pressure-reducing valve, faced and drilled.
1—4″ std. globe valve, faced and drilled.
1—4″x2″ std. flanged tee, faced and drilled.
1—4″ ditto.
1—4″ ditto elbow.
14—4″x9″ standard flanges, faced and drilled.
1—4″x20″ extra heavy reducing flange, faced and drilled.
1—4″x10″ ditto flange, faced and drilled.
7 pcs. 4″ pipe—80′ 0″ total—extra heavy.
Threads, 14—4″.

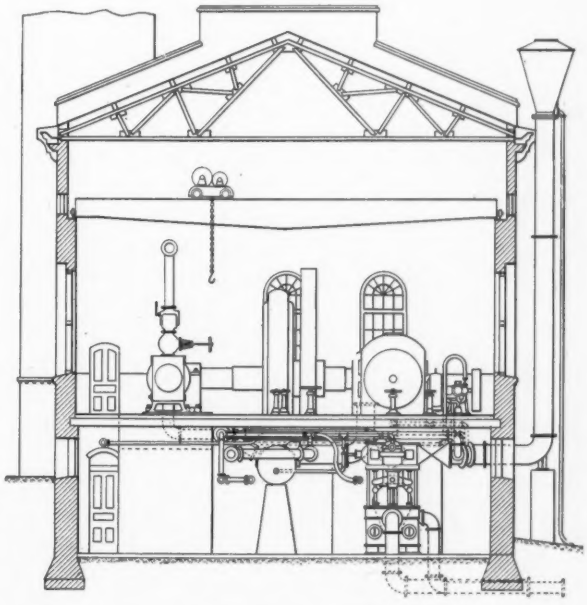

FIG. 4. VERTICAL SECTION THROUGH ENGINE ROOM

Labor making on and refacing standard flanges, 14—4″.
3—4″ std. weight 90° bends, 2′ 0″ rad., 3′ 0″x3′ 0″, ctrs. with 8—1″x9″ std. flanges, made on, refaced and drilled.

1—4″ std. weight 90° bend, 3′ 0″x7′ 3″ ctrs., 2′ 0″ rad.,
2—4″x9″ std. flanges, faced and drilled.
Bolts and corrugated copper gaskets for standard joints, 16—4″.

Steam Lines to Auxiliaries

Steam lines for the auxiliaries are listed in the same way, and with the exception of specifying the bends, it will not be necessary to give the long list of fittings required for this line.

1—2.5″ std. weight U bend, 1′0″, radius of bend, 2′ 0″, center to center, 2′ 6″x8′ 6″ center to face of 2—2.5″x7″ std. flanges, faced and drilled.

All this information is necessary in describing bends, as it allows the manufacturer to figure the amount of straight pipe necessary to make the bend.

1—5″ std. weight 90° bend 7′ 0″x4′ 0″ center to face of 2—5″x11″ extra heavy flanges, made on and refaced and drilled, 3′ 0″ radius of bend.

1—5″ std. weight 90° bend 2′ 0″x2′ 0″ centers to face of 2—5″x11″ extra heavy flanges, made on re-
5″x11″ extra heavy flanges, made on and refaced and drilled, 1′ 8″ radius of bend.

Steam line to pumps, which will furnish the steam connection, is listed in the same way as the previous lines, and as it is all straight work, it will not be necessary to list them in this article.

Exhaust Steam Connections

The exhaust connections may then be taken care of, the same method being followed as for steam. Of course, a much lighter weight of material is used on exhaust connections. Material specified by manufacturers as being good for 50-lb. working pressure being ordinarily used. No restrictions as to finish of flanges, gaskets, etc., are necessary. Cast-iron, low-pressure fittings, flanges screwed on pipe, low-pressure valves and rubber gaskets would be a good specification for this line.

Notice should be taken of the 22-in. horizontal automatic relief valve, placed near the condenser, to permit instant relief of the condenser in the event of the vacuum being broken, which may happen from a variety of causes. The exhaust relief valve is so placed as to allow the steam to lift the valve disk and blow off to atmosphere through the exhaust head. When the vacuum in the condensing system is restored, the disk returns to its seat, and the vacuum is held until another break occurs.

The exhaust head is used for the purpose of preventing the water of condensation from escaping to the roof, a very small amount of exhaust leaving the head to the atmosphere. The vertical pipe leading to the head is generally made of spiral riveted pipe, galvanized, used because of its lightness, cheapness, and good wearing qualities.

Miscellaneous Piping

The boiler feed suction and discharge pipe may then be taken. The suction lines of standard material, and the discharge lines to the boilers made of all brass pipe, fittings, flanges, and valves. The brass material is used as an added precaution against rust or deterioration from the action of the water, as this material is tough and will last the life of the boilers without renewal.

The drips and drains are generally made of the same quality of material as that to which they are attached. Each layout presents individual features which can not be entirely grasped from the drawings, and only an approximate estimate of small material needed, can be made. Steam traps, pumps, receivers, etc., have to be provided to suit the layout of the plant. Bracing, supports, and anchors generally, are not detailed, but are a part of all estimates of piping material, and should be so located as to afford steady lines, free from vibrations of all kinds, and to take care of all expansion strains by anchoring the lines at certain points, so as to throw the expansion on the parts of the piping especially designed for the purpose, viz., pipe bends, expansion joints, etc.

A NEW TYPE OF HIGH SPEED STEAM ENGINE.

THIS latest engine is the joint production of F. H. Ball, the well-known engine designer, and his son, F. O. Ball. In the early days of high speed engines there was great similarity in the valve gears of all makes, but in later years there has been a divergence in the line of development followed by designers of this class of engines. Some have sought a refinement of efficiency by the use of complicated valve gear. Others have claimed that the increased cost of maintenance of complicated valve gear on high speed engines and the greater liability of interrupted service more than offsets the small gain in efficiency that may be realized from a multiplication of the valves and valve mechanism, and that where high efficiency is desired a much better plan is to use a compound engine of simple design, because it is more economical of steam than any simple engine, even with the most complicated valve gear.

Mr. Ball and his son have continually held to this view, and have sought to attain the extreme of simplicity and fewness of parts. The Duplex-Compound engine is in this line of development, and now this newest engine, called the "Angle-Compound," is another step in the same direction.

The casual observer of high speed engines does not understand that. with a horizontal engine, the inertia thrust of the reciprocating parts which will rock a foundation badly will. if transferred into a vertical plane. be easily resisted by the same foundation. The engine then has no rocking tendency, and. therefore, seems to be balanced.

The usual practice of engine designers is to counterbalance to the extent of transferring the largest part of the horizontal thrust to a vertical plane, leaving only such an amount of horizontal thrust as will be safely resisted by the usual foundation.

Keeping this in mind, it is evident that, by combining a horizontal and vertical engine on the same crank pin, the total amount of horizontal thrust may be neutralized by counterbalance; and when the counterweight is in a vertical plane, it is opposed by the reciprocating parts of the vertical engine, so that at four points of the stroke a perfect balance is realized, and between these four points there is no position of the crank when any appreciable unbalanced condition is found.

In the Angle-Compound engine, herewith illustrated, the conditions for perfect balance are brought about by making the low pressure piston a very light, conical-shaped, steel structure of about the same weight as the ordinary cast iron piston in the high pressure cylinder. The low pressure engine is made the vertical engine because it is thought desirable to have the larger piston rest on the piston rod rather than to drag in a horizontal cylinder.

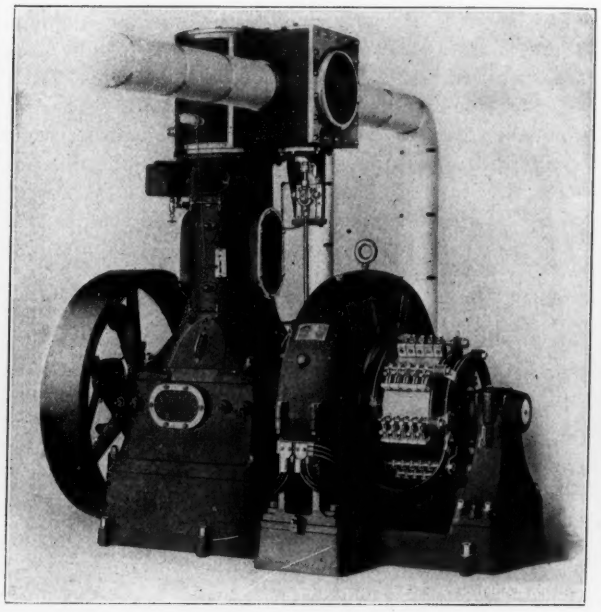

FIG. 1. AN ANGLE-COMPOUND RECENTLY PUT IN OPERATION AT THE AMERICAN ENGINE CO.'S PLANT

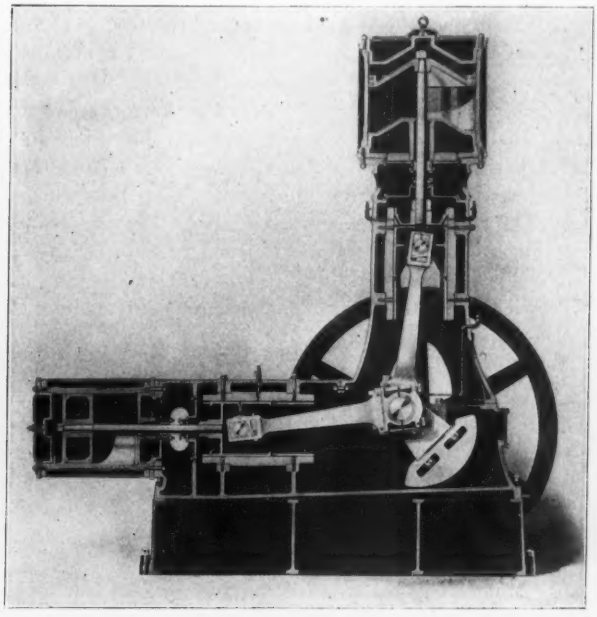

FIG. 2. SECTION, THROUGH THE HORIZONTAL AND VERTICAL CYLINDERS

It will be seen, by reference to the several views of the engine, that the high pressure valve is driven by the usual valve gear and shaft governor, and the low pressure by an eccentric, which is enclosed in an oil-tight casing, and connected with the oil-circulating system of the engine. From this eccentric a rod drives direct to the low pressure valve stem, which is guided by a crosshead carried in guides, as shown, and this crosshead and guides are also included in the oil-circulating system of the engine. This oil-circulating system is similar to that used on the American-Ball engines, with which engineers are familiar, except that the oil is pumped directly to the gravity storage tank on the low pressure frame, which is kept constantly overflowing by the supply delivered to it from the pump.

A double stuffing box on the valve stem and bulk heads, and stuffing boxes on both piston rods, prevent the water drip from mingling with the oil of the circulating system. The water drip from all these stuffing boxes is carried off by concealed piping so that the engine is never untidy in appearance.

A new departure has been made in this engine in the arrangement of the crosshead and guides, which are of the bored type. It will be noticed that the crosshead is a single piece, without the usual adjusting shoes, while the guides are made adjustable. These guides are carried in bored seats, and a projection from the back of the guide fits between the supports so as to resist end thrust. One of the guides is secured to the support by screws, and is adjustable only by means of shims, but the other has a pair of screws at each support to provide for delicate adjustments, and the guide is securely held against these adjusting screws by a bolt that locks the adjustment when set up.

For large powers these engines, combined in pairs, with the generator or belt wheel between them, make an exceedingly compact unit. In these combinations the engines are used as double compounds when run noncondensing, or where condensing water is available, as four-cylinder triple-expansion engines. In the latter case one horizontal engine is the high pressure, the other horizontal the intermediate pressure, and the two vertical engines combined are the low pressure, thus giving a large area of low pressure piston without using any pistons of very large diameter.

GAS ENGINES AND PRODUCERS

THE GAS ENGINE'S PROBABLE FUTURE*

By Sumner B. Ely

IN TRYING to forecast how far the gas engine is likely to displace the steam engine, no treatment of apparatus is attempted, merely the detail specific reasons for the general conclusions reached.

The fuel saving a gas engine will effect over the steam engine is well known. We all appreciate its high mathematical heat efficiency, also that the cooling water, used to keep down excessive temperatures that would otherwise prevent proper mechanical working, carries away so much heat that this high efficiency is nearly cut in half. Furthermore, useful heat is thrown away in the exhaust so that an engine in practice develops perhaps 25 per cent efficiency. While many tests show much more than this, 25 per cent is probably a conservative figure that can be obtained in practice. It must always be remembered that a gas engine gives its maximum efficiency only when carrying full load and that the efficiency falls off as the load is decreased.

For a comparison with the gas engine, it is doubtful if a compound condensing steam engine will do better than 12 or 13 per cent efficiency. A boiler with its furnace that gives 70 per cent is a very good one and combining this with the steam engine we have a total efficiency of less than 10 per cent against the gas engine's 25 per cent.

The above case is applicable to blast furnace work, where the common practice is now to burn the blast furnace gas under steam boilers; or it is a comparison where natural gas is used.

If, however, the gas for the gas engine is generated from coal in a gas producer, then the efficiency of the gas producer must be taken into account.

Taking all of the above efficiencies into consideration and also the load factor, we may perhaps say of the average case met with in practice, that about one-half less fuel will be required by the gas than by the steam engine.

Some articles have been published stating that the gas engine on blast furnace gas would use for the same work only one-fifth or one-sixth of the gas required by a steam boiler and engine. Most of these articles are based either on calculated results or exceptional tests, and the conservative engineer will be doubtful of such enormous savings working day after day in actual practice.

Let us now turn to the disadvantages of the gas engine. One of the most serious is its inflexibility regarding overloading. As already stated, the maximum efficiency is at maximum load and consequently to get economy, the builders have generally in the past sold an engine which would just about carry the load with practically no margin of power left. In most shops, particularly with the smaller engines, there is always a tendency to add more and more load from time to time as new machinery is added or extensions are built. A steam engine, if necessary, can take steam full stroke and its power will be greatly increased. To be sure, its efficiency falls off, but naturally the purchaser will consider excess power of far more convenience if not of actual value. He does not care to buy a new engine every time he belts a few more machines onto his shafting.

The maximum load consideration always comes up in the case of varying loads. For instance, after designing as heavy and large flywheels as practicable, suppose that we will need 700 h. p. the greater part of the time, but occasionally as high as 1,000 h. p. will be needed. A steam engine rated at 700 h. p. if overloaded 38 per cent, viz. to 1000 h. p., would not show much falling off of efficiency. A gas engine to give a good efficiency should not carry less than 80 or 85 per cent of its maximum capacity. This would mean we would have to install a gas engine of at least 800 h. p., or better still, 850 h. p.

A great many figures have lately been published including load factor, interest on investment, depreciation, etc., etc., but without going into this, suffice it to say that with coal costing about $2 per ton or more, a resultant saving (except in exceptional cases) can be shown in favor of the gas engine, this being more or less depending on the many conditions which always enter the problem.

As already stated, in the average case the gas engine shows about one-half the consumption of the steam engine.

The difficulty of reversing a gas engine is often advanced against it, but with the many satisfactory clutches, both for very large and small work, this objection does not mean much.

I want to speak now of what, to my mind, is really the key to the general use of gas engines, and that is the production of a proper gas for the engine to run on. Experience shows that gas engines can be designed (not that all are) which will run success-

*A paper read before the American Society of Mechanical Engineers.

fully from a mechanical standpoint, experience also shows that blast furnace gas can be cleaned successfully, also that natural gas can be used, also that gas can be made from coke or anthracite coal, but it has not shown that we have an altogether satisfactory gas producer for bituminous coal, and until such is put on the market it is hard to see how the general adoption of gas engines can take place. Bituminous coal is our great commercial fuel and the universally accepted engine must run on it.

It is not an easy matter to get a gas from bituminous coal which is clean. For gas engine work, if much dirt is present, it cakes and bakes on the cylinder walls, becomes incandescent and explodes the charge at the wrong time. There are, however, one or two makes of producers that come very near being generally satisfactory, but are complicated by washing and cleaning apparatus, and to obtain economy it is often necessary to sell a byproduct. Installations for small plants are hardly expedient.

There is, however, at present, considerable experimental work going on, and I for one, believe it will not be many years before we see gas engines producing a brake horsepower per pound of bituminous slack coal, from a simple and efficient gas producer.

To sum up the previous remarks, to my mind before the gas engine can come into very general use we must first have a simple and satisfactory bituminous gas producer. Granting that this will probably come, the gas engine still for general use is hampered by its inability to carry overloads. However, as time goes on and the price of fuel goes up, as it must, due to the economic law of supply and demand, we may expect a good many gas engines to replace steam. First, however, before economy the general user appreciates the flexibility of the steam engine, and I cannot believe that the gas engine will ever entirely displace the steam engine. The gas engine will fit into certain conditions and places admirably and its field will undoubtedly be enormously increased with the advent of high-priced fuel and a proper gas producer.

GOULD COUPLER PRODUCER GAS PLANT

PRESSURE PRODUCERS SUPPLYING GAS OF 105 B. T. U.

AT DEPEW, N. Y., which is near Buffalo, are located the works of the Gould Coupler Co. The name Gould is undoubtedly familiar to most of us on account of the storage battery made by this concern. The battery, although an important part of the company's output, is not by any means the only product made, as the company also gives its attention to railway supplies, such as tender and pilot couplers, steel platforms with friction buffers, locomotive and car axles, and a number of other steel castings. The manufacture of all these products calls for a plant covering 30 acres of ground and the employment of 2,400 men. Naturally, the works are divided into a large steel plant, malleable iron plant, storage battery plant, etc. The company has its own foundry, machine shop and everything complete to manufacture and finish the products mentioned.

From the previous description it will be evident that the company has an extensive plant and one requiring a great deal of power to operate. Originally this power was supplied by a 1000 h. p. steam plant which is still in operation. With the growth of the works more power was required, and the increased demand is now supplied by a producer gas engine plant capable of developing 705 h. p., this power being subdivided into three gas engine units, each rated at 235 h. p. and drawing gas from a large pressure tank supplied by two producer units.

Even with the addition of the gas engines the demand for power has not been fully met, and it is the intention of the company to install in the near future two 500 h. p. motor-generator sets which will utilize Niagara power. With the motor-generator sets installed the company will have at hand something like 2700 h. p., which it is estimated will be a great sufficiency to work the plant to its fullest capacity. In the present article only the gas engine plant will be given attention, the general layout being shown in Fig. 1.

Producer Installation

Gas for the engines is supplied by producers operating on the Loomis-Pettibone system, the installation consisting of two sets of gas producing apparatus. Each set has two generators and one boiler, and both utilize a wet scrubber and a dry scrubber. The generators are all 7 ft. in diameter and 14 ft. high, boilers 4 ft. 6 in. in diameter and 21 ft. high, each containing 88 3-in. flues. The scrubbers are 6 ft. in diameter and 26 ft. high, these dimensions indicating a considerable capacity for generating gas.

As usual, these producers operate on the downdraft principle, the air being admitted to the charging door at the top of each producer, the necessary suction to draw the gas through the fuel bed and the other apparatus of the producer set being supplied by a Root blower located beyond the wet scrubber. The blower, or rather exhauster, is driven by a 25 h. p. New York Safety engine, and delivers the gas to a holder of 15,000 cu. ft. capacity. By this method of drawing the gas down through the fuel, the volatile matter and distillates are forced to pass through the incandescent bed of coal, and are converted into a fixed gas, thus avoiding the use of tar extracting machinery.

In the boiler to which the hot gases are passed direct from the generator, steam is generated, and reverse runs of this steam are frequently made through

the generator for the purpose of breaking up the fuel bed. The water gas formed adds slightly to the heat value of the gas, but with emphasis on the slight, as the gas only averages 105 B. t. u. A value of 105 B. t. u. is unusually low, but is obtained from a poor quality of bituminous coal.

From one of the company's sidings the coal is dumped from a car to a coal crusher, from which it is

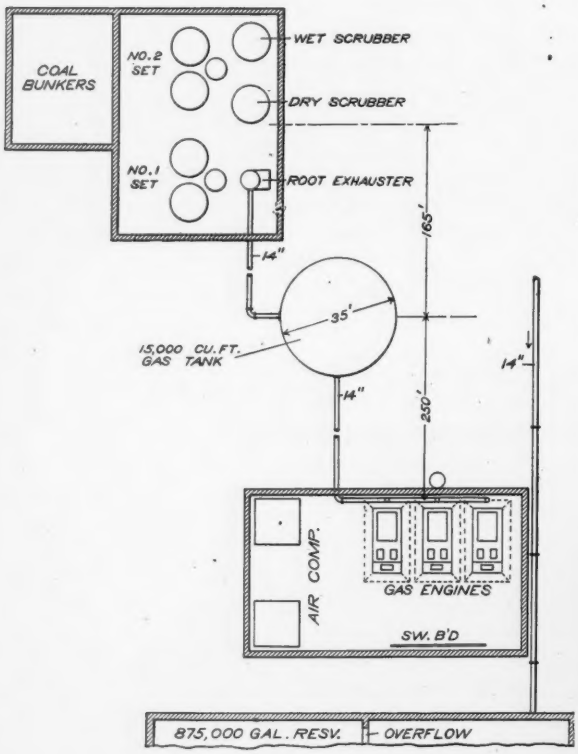

FIG. 1. LAYOUT OF PRODUCER AND GAS ENGINE PLANTS

elevated by a bucket conveyor to a horizontal apron conveyor which carries the coal some distance to the operating floor of the producer plant. A portion of this floor is shown in Fig. 2, and in the foreground one of the charging doors into which the coal is shoveled as required. On an average about 2.2 lb. of coal per kw.-hr. at the switchboard are used.

Engine Room

About 400 feet distant from the producer plant is the engine room, which is located in a separate building 48 ft. wide, 85 ft. long and 30 ft. to the eaves. Besides three gas engine units the building contains two motor driven air compressors and the switchboard on the main floor, and in the basement a large storage battery plant and pump room with three circulating pumps and one boiler feed supplying water to the steam end of the plant.

As previously stated the engines are three in number, each rated at 235 h. p. and of the three cylinder vertical type made by the Westinghouse Machine Co., of Pittsburg. They are all alike and have cylinders 19 by 22-in. Two of the engines are shown in Fig. 3. Each engine is supplied with gas from the holder, which is 250 ft. distant from the plant. The gas is conducted through a 14-in. pipe to the engine room and a 7-in. pipe conveys it to the cylinders of each unit, passing on its way through a regulator which reduces the pressure from 2 in. of water in the tank to practically atmospheric for the engines.

Each cylinder is provided with two valves, one inlet and the other exhaust, both of the mushroom or poppet type and seating vertically. The inlet valve together with its bonnet or cage forms a one-piece plug similar to the igniter. The exhaust valve extends downward and may be readily taken out through an opening in the cylinder head. A separate cam controls each valve, the cam motion being communicated to the valve by rods and levers terminating in roller contacts held to the cam by springs.

Besides water jacketing the cylinders, the exhaust valves are also cooled. For this purpose the valve stem is made with an internal concentric tube rising to the valve head, cold water enters through a flexible rubber hose connection, ascends through the outer space and descends through the inner tube, which operates as a water seal.

When the gas has done its work, it is exhausted

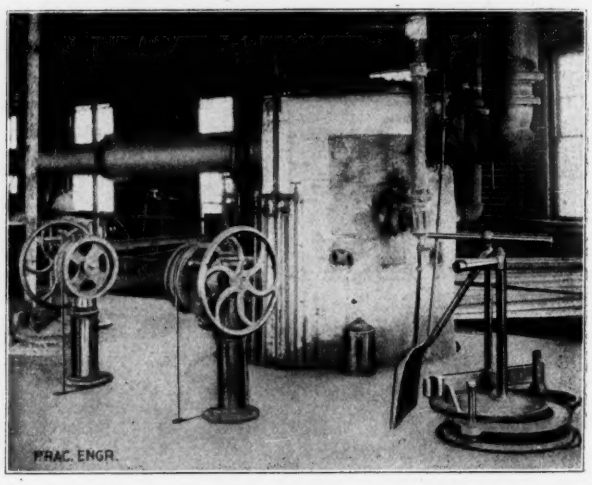

FIG. 2. OPERATING FLOOR OF PRODUCER PLANT

from each cylinder through an 8-in. pipe to a concrete duct with rounded corners and dimensions of 3½ by 5 by 25 ft. From this common reservoir the exhaust gases are discharged to atmosphere through a 36-in. steel stack, 45 ft. high and located just outside the building.

Ignition is make-and-break, or as it is usually termed, a hammer break igniter is employed, consisting of two poles, one stationary and the other movable. The movable pole is actuated from the outside by a trip and interrupts the current at the beginning of each power stroke. The opposing contact points are

protected by tips of platinum in order that the rubbing surfaces may withstand the severe service to which they are subjected.

Current for ignition may be obtained from any one of three different sources, the principal source being a Deihl dynamotor run from the 220-v. mains. This

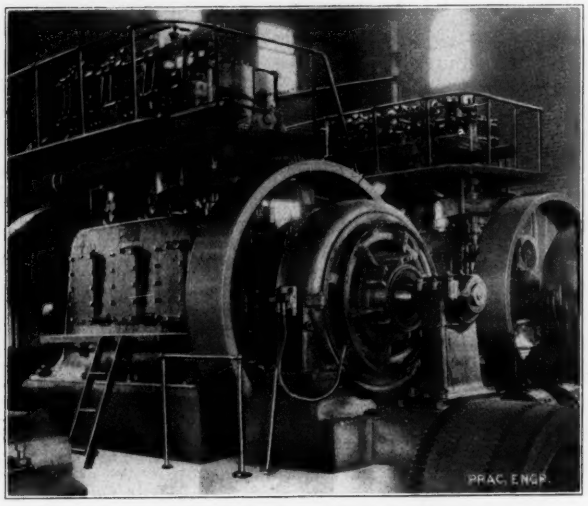

FIG. 3. TWO OF THE GAS ENGINE UNITS

machine has a capacity ½ kw. and furnishes ignition current at 110 v. through two 110-v. 16-c-p. lamps in parallel. The second source is a storage battery consisting of two sets of four cells each, arranged so that one set can be charged while the other is discharging. Each cell delivers 2½ v., so that the battery has a voltage of 10, which in connection with a spark coil for each engine is sufficient to ignite the gases. If for any reason these two sources should fail, ignition current may be drawn from four cells of the main storage battery located in the basement.

Lubrication

Lubrication of the engines is effected by a gravity oiling system. The oil is stored in a 300-gal. tank located outside of the building and is allowed to flow by gravity to a second tank of 175 gal. capacity located in the basement. From here the oil is forced by air pressure to a 100-gal. tank supported on the roof trusses, so that it can flow to the engines as required. In the crank case splash lubrication is employed. The oil is maintained at the proper level and is frequently cleansed by means of a Cross oil filter from which it is returned to the storage tank and mixed with the general supply.

Cooling Water

Cooling water for the gas engines is taken from a large open air reservoir which is masonry lined and has a capacity of 875,000 gal. By a partition wall this reservoir is separated from a second reservoir of the same size, the water in this space being used for the wet scrubber in the producer plant. If required these reservoirs may be filled from the city mains, but this has never been necessary as all waste water about the plant which is clean and suitable, is turned into these reservoirs and in addition all the rain water collected from a 5-acre area of roof on the steel plant. Besides cooling the gas engine cylinders the water is also used as boiler feed, and a considerable amount is taken in this way, as 1000 h. p. of boilers must be supplied.

A Worthington two-stage centrifugal pump circulates the water through the cylinders of the three gas engine units. This pump has a 4-in. suction and will deliver 150 gal. per minute against a pressure of 60 lb. It is driven direct connected by a 15-h. p. Bullock motor. After passing through the cylinders the water is returned to the reservoir at a point remote from the suction.

Method of Starting

Compressed air is used for starting the engines and is taken from the general supply of the plant, which is maintained at a pressure of 90 to 100 lbs. The air is admitted at this pressure to one of the three cylinders of the engine, while the other two operate on gas. In this way but very little is required for starting. The air is supplied by two Ingersoll Sergeant air compressors, two-stage and cross connected through an intercooler. The high-pressure cylinder has a diameter of 14¼ in., the low pressure 22¼ in. and the stroke is 14 in. At 150 r. p. m. each compressor will deliver 900 cu. ft. of free air per minute. Each compressor is driven by a 175-h. p. Bullock motor. Provision has been made for a third set of the same capacity. The air required to start

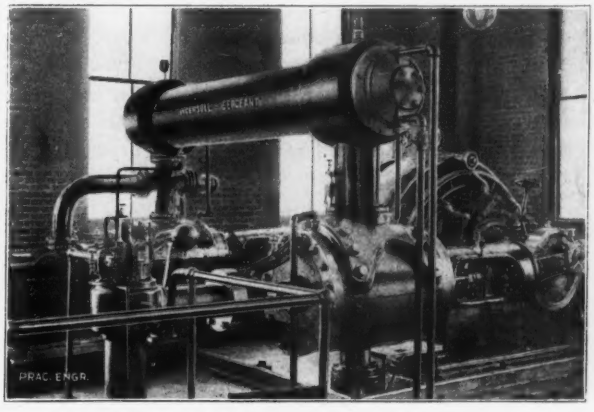

FIG. 4. MOTOR DRIVEN AIR COMPRESSOR

the engines is taken from the main supply tank, which is 5 ft. in diameter and 15 ft. high.

Electrical Equipment

To each gas engine unit, is direct connected, a 150-kw. direct-current generator delivering current at 240 v. Under normal conditions the speed is 200 r. p. m. To handle the entire load, the three machines are required. A considerable portion of the load is

devoted to power, as there are a large number of motors distributed throughout the plant. The lighting load is comparatively small, and consists principally of Adams-Bagnall arcs and Cooper-Hewitt mercury vapor lamps; only a very small number of incandescent lights are used. A larger proportion of the current goes to the storage battery department where it is used electrolytically in making storage battery plates. For regulation a C. & C. booster set is used, and a Gould storage battery of 112 cells and 800 amp.-hr. capacity.

To control the generators and the load, the plant possesses a 14-panel black enamel switchboard, consisting of 5 feeder panels, 2 air compressor motor panels, 2 panels for the booster and battery, 1 panel for parallel service between steam and gas plant, 1 tie panel, and 3 generator panels. The board is equipped with the usual direct-current instruments of Weston and Keystone make, Thompson wattmeters, I. T. E. and G. E. circuit breakers, etc.

The plant has been giving satisfactory operation, although some little trouble was encountered from impure gas. D. B. Clinch is chief engineer in the plant and furnished much of the information contained in this article.

GASOLINE VS. ALCOHOL AS PRODUCER OF POWER

THE technologic branch of the United States Geological Survey, under the direction of J. A. Holmes, has recently completed an elaborate series of tests on the relative value of gasoline and alcohol as producers of power. The tests, over 2,000 in number, probably represent the most complete and exact investigation of the kind that has been made either in this country or abroad, and includes much original research work.

Professor R. R. Fernald, engineer in charge of the gas producer section and professor of mechanical engineering in the Case School of Applied Science, Cleveland, Ohio, was in general charge of the tests. R. M. Strong, formerly connected with the engineering department of Columbia University, had personal supervision of the work. He was assisted by a corps of specially trained men.

These tests were conducted at the Fuel Testing Plant of the Geological Survey at Norfolk, Virginia, and show the following results in regard to the comparative fuel consumption of 0.73 specific gravity gasoline and commercial completely denatured alcohol, per unit of power.

Equal Fuel Consumption By Volume

Correspondingly well designed alcohol and gasoline engines, when running under the most advantageous conditions for each, will consume equal volumes of the fuel for which they are designed. This statement is based on the results of many tests made under the most favorable practical conditions that could be obtained for the size and type of engines and fuel used. An average of the minimum fuel consumption values thus obtained, gives a like figure of 0.8 pint per hr. per b. h. p. for gasoline and alcohol.

Considering that the heat value of a gallon of the denatured alcohol is only a little over six-tenths that of a gallon of the gasoline, this result of equal fuel consumption by volume for gasoline and alcohol engines probably represents the best comparative value that can be obtained for alcohol at the present time, as is also indicated by continental practice. Though the posssibility of obtaining this condition in practice here has been thoroughly demonstrated at the government fuel testing plant, it yet remains with the engine manufacturers to make the "equal fuel consumption by volume" a commercial basis of comparison.

Test Conditions

The gasoline engines that were used in these tests are representative of the standard American stationary engine types, rating at 10 to 15 horsepower, at speeds of from 250 to 300 r. p. m., while the alcohol engines were of similar construction and identical in size with the gasoline engines.

The air was not preheated for the tests on alcohol and gasoline, and the engines were equipped with the ordinary types of constant level suction lift and constant level pressure spray carburetters. Many special tests with air preheated to various temperatures up to 250 deg. F., and tests with special carburetters were made, but no beneficial effects traceable to better carburation were found when the engines were handled under the special test conditions, including constant speed and best load.

The commercial completely denatured alcohol referred to is 100 parts ethyl alcohol plus 10 parts methyl alcohol plus ½ of one part benzol and corresponds very closely to 94 per cent by volume or 91 per cent by weight ethyl alcohol (grain alcohol). No detrimental effects on the cylinder walls and valves of the engines were found from the use of the above denatured alcohol.

The lowest consumption values were obtained with the highest compression that it was found practical to use; which compression for the denatured alcohol ranged from 150 to 180 lb. per sq. in. above atmosphere.

Decrease in Pure Alcohol Lessens Thermal Efficiency

Eighty per cent alcohol (alcohol and water) for use in engines of the present types would have to sell for at least 15 per cent less per gallon than the denatured alcohol in order to compete with it. The

minimum consumption values in gallons per hour per brake horsepower for 80 per cent alcohol is approximately 17.5 per cent greater than for the denatured alcohol used, or for gasoline.

A series of tests made with alcohol of various percentages by volume ranging from 94 per cent to 50 per cent showed that the minimum consumption values in gallons per hour per brake horsepower increased a little more rapidly than the alcohol decreased in percentage of pure alcohol. That is, the thermal efficiency decreased with the decrease in percentage of pure alcohol. This decrease in thermal efficiency or increase in consumption referred to pure alcohol is, however, comparatively slight from 100 per cent alcohol down to about 80 per cent alcohol. Within these limits it may be neglected in making the calculations necessary to compare the minimum consumption values for tests with different percentages of alcohol.

The nearer the alcohol is to pure, the greater the maximum horsepower of the engine. The per cent reduction in maximum horsepower for 80 per cent alcohol as compared with that for denatured alcohol used was less than 1 per cent, but the starting and regulating difficulties are appreciably increased.

Gasoline and Alcohol Mixtures

With suitable compression, mixtures of gasoline and alcohol vapors (double carburetters) gave thermal efficiencies ranging between that for gasoline (maximum 22.2 per cent) and that for alcohol (maximum 34.6 per cent), but in no case were they higher than that for alcohol. The above thermal efficiencies are calculated from the brake horsepower and the low calorific value of the fuel, which for the gasoline was 19,100 B. t. u. per lb. and for the denatured alcohol was 10,500 B. t. u. per lb.

Alcohol Used in Gasoline Engines

As has been previously published, alcohol can be used with more or less satisfaction in stationary and marine gasoline engines, and these gasoline engines will use from one and one-half to twice as much alcohol as gasoline when operating under the same conditions. The possibilities, however, of altering the ordinary gasoline engine as required to obtain the best economies with alcohol are very limited; for the amount that the compression can be raised without entirely redesigning the cylinder head and valve arrangement is ordinarily not sufficient, nor are the gasoline engines usually built heavy enough to stand the maximum explosive pressures, which often reach 600 to 700 lb. per sq. in. With the increase in weight for the same sized engine designed to use alcohol instead of gasoline, comes an increase in maximum horsepower of a little over 35 per cent, so that its weight per horsepower need not be greater than that of the gasoline engine, and probably will be less.

The work was taken up to investigate the characteristic action of fuels used in internal combustion engines with a detailed study of the action of each fuel (gasoline and alcohol) as governed by the many variable conditions of engine manipulation, design and equipment. These variables were isolated, so far as possible; their separate and combined effects were determined; worked out under practical operating conditions; and lead up to the conditions required for minimum fuel consumption. The results show the saving that can be obtained over conditions for maximum consumption, and also establish a definite basis of comparison under conditions most favorable to each fuel. This latter is a point of much commercial interest and a study of the comparative action of gasoline and alcohol may be of great service in solving some of the general internal combustion engine problems where other than liquid fuels are used.

COST OF PRODUCER GAS POWER IN REFRIGERATING PLANT

By G. P. Risley

In the following is a tabulated report of 1 year's cost of operation in Jas. K. Devins' refrigerating plant at Atlantic City, N. J. The plant is operated by a 40-h. p. single cylinder Thompson automatic cutoff producer gas engine and a 40-h. p. Berger gas producer. The report covers a period from Oct. 26, 1906, to Oct. 29, 1907, and will undoubtedly be of interest to brother engineers:

b. h. p. of compressor cylinders	18
h. p. required to operate brine pump	3
h. p. required to operate triplex pump	2
Total h. p. of machines	23
Losses in belting, pipe friction, etc., h. p	11
h. p. developed by engine	34
Total fuel consumption per year, lb	139,200
Total h. p.-hr. per year (360 days of 10 hr.)	122,400
Av. coal consumption per b. h. p.-hr. (including holdover), lb	1.14
Cost of coal per year at $3.85 per long ton	$ 239.28
Cost of coal per b. h. p.-hr. (including holdover loss)	0.0019
Cost of oil	22.50
Cost of repairs	9.00
Wages of engineer for 1 yr	780.00
Total cost of developing power for 1 yr	1,050.78
Total cost per b. h. p.-hr. (including attendance, repairs, etc.)	0.0085

Circulating water taken from well on premises, cost nothing.

Air is the mechanical mixture by weight of 77 per cent of nitrogen and 23 per cent of oxygen, and by volume, 79 volumes of nitrogen and 21 volumes of oxygen. It takes 11.54 lb. of air theoretically to burn 1 lb. of carbon, while in practice, from 18 to 24 lb. of air for each pound of coal burned is ordinarily allowed.

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WASHING OF COAL

For power plant work coal has not, as a rule, been washed, as it is found easier and not materially more expensive to handle the extra amount of ash and to fire the extra amount of coal needed rather than to subject it to a washing process. There is no question but that washed coal gives a better fire and a bigger output from boilers than the unwashed, but this has not to any extent influenced the situation. The results of practice in coal washing at the Sydney mines of the Nova Scotia Steel & Coal Co. show what may be expected as an improvement in the quality of the fuel from the washing of coal. At these mines the process is carried out to provide coke for smelters, but washed coal is also used under boilers where an extra amount of power is required.

In this plant 300 tons of coal per day were estimated as the capacity, but by careful arrangement of elevators and means for disposing of waste, the capacity was increased to 500 tons.

Coarse screenings are emptied into an elevator pit, lifted and carried to the breaker house, where it is run through the rolls and the product is then carried by a second elevator to a shaking screen with ½-in. perforations. The screenings fall to a third elevator pit, and all parts larger than ½-in. pass over the screen into breaker rolls and thence to the same pit, from which it is raised to a storage tank. From the storage it is taken by a scraper conveyor to a ⅜-in. screen, where the coarse and fine particles are separated by a shaking motion and the use of a flushing jet. All material less than ⅜-in. is taken by the jet of water to the fine jigs and the remainder, between ½ and ⅜ in., is sluiced to the coarse jigs. From these jigs the coal is taken to a washed coal bin and the slate to a waste bin.

Results of the washing process are that the combustible matter on five monthly tests was raised from an average of 27.56 to an average of 34.94 per cent; the fixed carbon raised from 56.43 to 61.71, the ash reduced from 16.19 to 4.33, and the sulphur reduced from 2.18 to 1.51. This would raise the heating value per pound of fuel from about 14,000 to 14,600, and would reduce the labor of handling ash 75 per cent. It is found that the loss in washing was a total of some 21 per cent by weight, 12 per cent of this being the ash and sulphur removed, or a total coal loss of about 9 per cent in the process. Part of this was reclaimed, as the slate coming from the coarse jigs contained about 25 per cent of good coal and was rewashed, this recovered produce being used under the boilers.

The power required for treating this amount of coal was about 100 h. p. The increase in heat value per pound is about 4.3 per cent, which, on the basis of $1.50 a ton for coal, would give up an increase of 6 cents per ton in value. The loss is 21 per cent, which would be 31.5 cents a ton, and the cost for power per ton on the basis of 1 cent per horsepower hour would be about 2 cents. The washing process

would, therefore, seem to be a poor proposition for the coal seller, except for the fact that the unwashed coal would necessarily be sold at a much lower price than the washed. The increase in price would have to be to practically $1.90 in order to show any profit on the transaction. What value might be assigned to the lessened freight cost in transportation of coal from the mines to the user, the lessened cost of handling of ash and of the increased capacity of boiler plant, is a subject for speculation, and can only be settled by getting figures for individual cases, but from the experience of these mines the outlook is not encouraging.

WHY BE OPTIMISTIC?

With spring everything naturally takes a new start. The winter has been dull, but as the sun climbs higher, and ice bills take the place of coal bills, we all feel like chirping a little with the birds. And so this tendency is bound to be reflected in the affairs of the business world.

From most of the south and west comes the report that trade is improving, and the prospects are bright. This comes after a time of depression and the growth in volume of trade is slow and healthy, so that there is no likelihood of another slump as would have been the case had the recovery been instant.

The country has economized for 6 months and lived on its stored surplus; soon this surplus must be made good and that means orders. The basis of our spending power is our crops, and those were good last year and an early spring gives promise of abundant harvests this year.

Building is going on this season as merrily as ever and this calls largely for manufactured product.

There has been no war, no famine, no great disaster to cut down the productive or consuming capacity of the country. Perhaps we have increased our manufacturing facilities too fast in some lines, but the remedy for that is in trade activity, not stagnation. There is every reason why we should have good business, none except lack of confidence why we should not. Confidence, optimism, is all that is needed.

LUMBER VS. CEMENT

It is evident with the increasing cost of lumber, an increase which under present conditions is bound to go on and probably to become more rapid, some substitute for wood must be found in building operations. At the present time the yearly use of lumber is three times the yearly growth. The lumber industry is the fourth in importance in the country, but the distance of the supply from markets and the difficulty of getting it to market makes the cost of the output great, even with increased output and modern economical methods of cutting. For the year 1906, the total cut was 37,550,736 ft., of which 30,235,245 ft. were the soft woods and 7,315,491 ft. hard.

Most promising of the substitutes for lumber in building construction is concrete, either plain or reinforced. Cement in solid form and in block form has been used for buildings to a considerable extent, and reinforced with steel rods and beams, has become standard for factory and warehouse construction, as well as for bridges, dams, and sewers. In these latter uses it is, however, replacing other forms of masonry, but in the construction of floors, dwelling houses and roofs, cement is really displacing lumber. In the construction of walls, the essential requirement is that the structure shall be frost and moisture proof. Unfortunately, in a solid walled house, cement will permit the passage of frost and moisture to a considerable extent, so that, if plaster be put directly onto the cement, a cold wall and one to which paper or decorations will not adhere results. To get a dry wall, furring and a coat of lath and plaster must be added. Where cement block has been used with an air space and cement bond between the inner and outer parts of the wall, it is found that the frost and moisture will creep through the bond sufficiently to make trouble. In the best of the recent constructions, therefore, continuous air space is provided, either by making double air space which have bonds staggered, thus making a much longer path between outer and inner surface for the frost or moisture, or two walls are made practically separate and joined by some form of metal bond. If this bond can be so protected by galvanizing or otherwise that it does not rust, this last mentioned form seems the most likely to prove satisfactory.

The cement roof in pure form, which is really a cement tile, has, of course, the disadvantages of any construction of this nature. It must, to reduce weight, be a thin layer, and like any thin piece of stone is brittle. A breakage is difficult to replace so that the upkeep of the roof is likely to be heavy. Probably, however, not as heavy in the long run as for a roof made of shingle. In the form of asbestos mixed with cement, however, which gives a thin sheet having the hardness of stone, but without its brittleness, the cement roof has a form of comparatively small first cost and with a minimum cost to keep in order.

In floor construction, the cement must have reinforcing, as of itself it cannot take the bending strain necessary, but by using comparatively little steel and keeping the beams deep so that advantage is taken of the truss bracing of the rods, a concrete floor can be built with but small expense for the reinforcement. Several costly lessons have shown the danger of trusting a concrete floor to itself too soon after laying.

One form of cement work which seems well adapted for cheaper construction is the conversion of cement into a hollow tile which is laid up with cement mortar into walls and partitions, is coated on the outside and inside surfaces to give finish and is laid between beams of reinforced concrete to give the floors. In this way an absolutely fireproof construction can be secured at moderate expense and of maximum durability.

CHIMNEYS OF STEEL, BRICK AND CONCRETE

THEIR CONSTRUCTION AND DESIGN FROM TOP TO BOTTOM

By A. R. Maujer*

DRAFT for a boiler furnace may be produced by a fan or blower, by a steam jet, or by a chimney. Draft generated by a fan or blower is called mechanical draft, while draft generated by a chimney is natural draft. Mechanical draft is known as forced or induced, depending on the arrangement of the apparatus in relation to the furnace. In a forced draft system the air is supplied to the under side of the fire by the blower; the natural draft of the chimney, in such cases, is depended upon to draw off the gases from the top side of the fire. In an induced draft system the fan is located between the furnace and the stack and causes a suction of air through the fire to the fan, from which it is expelled up the stack. The natural draft of the stack is neglected in the calculations for such a system.

Under certain conditions it may be found expedient to install mechanical draft; where space is at a premium, or where the grade of fuel is very poor. A well proportioned chimney, however, offers two very real advantages, to wit: absolute reliability of operation, and the absence of maintenance expenses.

Cause of Draft in Chimney

Natural draft is caused by the difference in the weight of two columns of air of equal cross section having a height equal to the distance from the top of the grates to the top of the chimney, the temperature of one column being that of the outside air and the temperature of the other column that of the gases in the chimney. The draft varies with the temperatures, with the height of the chimney and with the variations of atmospheric pressure.

Resistance to Draft

To design a chimney to serve a given boiler installation it is necessary to consider carefully the type of apparatus, the quantity and nature of fuel to be burned, the arrangement of breeching and the distance of the plant above sea level. The apparatus and breeching will require a certain amount of draft to overcome the resistance they offer and the fuel will require a definite net amount of draft to supply a sufficient quantity of air to burn it successfully.

In regard to the resistance that the breeching and boilers offer, it is well to allow about 0.05 in. of water for each right angle turn in the breeching, and about 0.1 in. for each 100 ft. of length, depending on its cross-section and the nature of its lining. A brick lined breeching offers more resistance than an unlined one. The proportion of the cross-sectional area and the shape influence the resistance; a breeching of circular section and of ample area being the most efficient. It is good practice to make the sectional area of the breeching about 20 per cent greater than the area of the chimney. The resistance the boilers will offer depends very largely upon the type and the manner of baffling or the number of passes, and ranges from 0.1 to 0.5 in.

Draft for Various Coals

The net draft required at the fire varies greatly, and depends upon the nature of the fuel and the quantity to be burned per square foot of grate. The most freely burning coals are the good grades of bituminous, while the most difficult are the small sizes of anthracite. The draft required for various kinds of coal and at various rates of combustion is given by the Stirling Boiler Co. as follows:

DRAFT REQUIRED FOR VARIOUS RATES OF COMBUSTION

RATE PER SQ. FT. OF GRATE PER HR. IN LB.	DRAFT IN INCHES OF WATER	
	FOR BITUMINOUS	FOR ANTHRACITE
5	0.02 TO 0.04	0.06 TO 0.16
10	0.05 TO 0.10	0.16 TO 0.40
15	0.07 TO 0.15	0.30 TO 0.75
20	0.10 TO 0.25	0.45 TO 1.25
25	0.12 TO 0.32	0.65
30	0.17 TO 0.45	0.90
35	0.21 TO 0.58	
40	0.27 TO 0.75	
45	0.32 TO 0.95	

Height of Stack

Having determined the total amount of draft necessary to overcome all resistances and the surplus necessary to burn a given grade of fuel at a given rate, the height of the stack may be computed from the following rule, which is taken from the Stirling Boiler Co.'s "Book on Steam:"

Subtract the reciprocal of the absolute temperature of the stack gases from the reciprocal of the absolute atmospheric temperature and multiply the result by 0.52 and by atmospheric pressure in pounds per square inch. Then divide the required draft in inches of water by this product and the answer obtained will give the height of stack above the grate in feet.*

As the chimney itself offers resistance to the flow of the gases, it is necessary to allow for this resistance also. In a stack of average good proportions, the re-

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* $$H = \frac{D}{0.52\,P\left(\frac{1}{T} - \frac{1}{T_1}\right)}$$

Here H equals height of stack above the grate, in ft.; D equals required draft in in. of water; P equals atmospheric pressure in lb. per sq. in.; T equals atmospheric temperature, absolute; T_1 equals absolute temperature of stack gases.

sistance due to skin friction in the stack may be considered to be about 20 per cent of the theoretical draft. Therefore, in selecting a chimney to produce a given available draft, it is well to allow for the stack resistance by an increase of 25 per cent. Having established the required height, it remains to determine the proper diameter.

Diameter of Stack

For a stack having a height sufficient to furnish draft to maintain the required rate of combustion, the diameter depends upon the amount of coal to be burned per hour, and this quantity depends upon the amount of horsepower to be developed, and the quantity of coal required per horsepower per hour. The latter quantity depends on the grade of coal and efficiency of the apparatus and varies from 2.5 to 6 lb.

Prof. Kent gives an empirical formula for determining the size of a stack. His rule is based on a coal consumption of 5 lb. per horsepower per hour and is as follows:

To obtain the effective area of the stack, extract the square root of the height above the grate in feet; multiply by 3.33 and divide the horsepower to be developed by the product obtained. Where a rate other than 5 lb. per horsepower is expected, multiply the constant 3.33 by the ratio between 5 and the rate expected.*

To obtain the effective area from the actual, extract the square root of the actual area, multiply by 0.6 and subtract the product from the actual area.†

Knowing the effective area, the actual area may be obtained as follows:

To the effective area add 0.09, extract the square root of the sum and multiply by 0.6. To this product add 0.18 and the effective area of the stack. The result will be the actual inside area of the stack, which as shown in Fig. 6 is somewhat larger than the effective area.‡

In the writer's opinion, these rules give satisfactory results when used in connection with a knowledge of the amount of coal to be burned per horsepower per hour, and with a stack height sufficient to maintain the proper rate of combustion.

Steel Chimneys

There are in general use at the present time three types of chimneys, as determined by the class of material from which they are constructed. These are: steel chimneys, reinforced concrete chimneys and masonry chimneys.

Steel chimneys are divided into two groups, those which are guyed and those which are self-supporting. Guyed steel chimneys are the cheapest kind that can be erected. Their life, however, is not long, as the action of the flue gases disintegrates the steel on the inside and unless regularly and frequently painted they rust on the outside.

For temporary installations and where first cost is a big consideration they find considerable use. They are not very economic, however, as they are hardly ever lined and the loss due to radiation is rather high. The guy ropes are usually arranged in sets of four or six. One or two sets are used, depending more or less on the size of the chimney. Where one set is used, they should be fastened to the stack by means of a ring about two-thirds of the height of the stack above the base; where two sets are used the second set should be fastened to the stack about one-third of its height above the base.

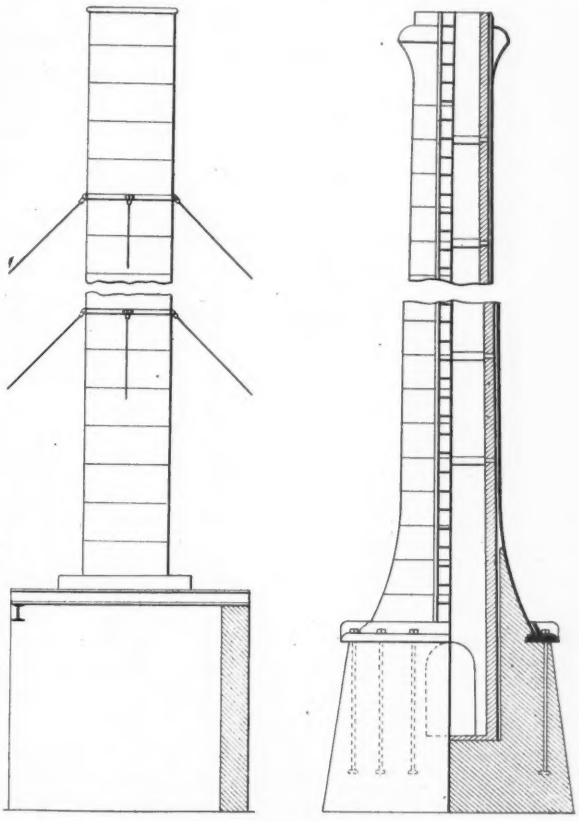


FIG. 1. GUYED STEEL STACK
FIG. 2. SELF SUPPORTING STEEL STACK

W. W. Christie quotes an empirical rule for determining the thickness of guy ropes, which is said to be adequate for general use and is as follows:

Multiply the height of stack in feet by the diameter in inches, extract the square root of the product and divide by 100. The result will be the least allowable diameter for each guy rope of a set of four.*

---

* $$E = \frac{H.P.}{3.33\sqrt{H}}$$

† $$E = A - 0.6\sqrt{A}$$

‡ $$A = E + 0.18 + 0.6\sqrt{E+0.09}$$

In these formulas E equals effective area of stack in sq. ft.; H. P. equals h. p. to be developed at the rate of 1 h. p. per 5 lb. of coal per hr.; H equals height of stack above grate, in ft.; A equals actual area of stack in sq. ft.

* $$\frac{\sqrt{HD}}{100}$$

Where H equals height of stack in ft. and D equals diameter of stack in inches.

Self-supporting chimneys require less space than masonry chimneys, are lighter and hence require smaller foundations. Very often their first cost is less than that of masonry chimneys, especially if they are not lined for their full height. They require painting at least every 2 yr., the cost of which constitutes a maintenance expense which should be taken into consideration when the type of chimney is being se-

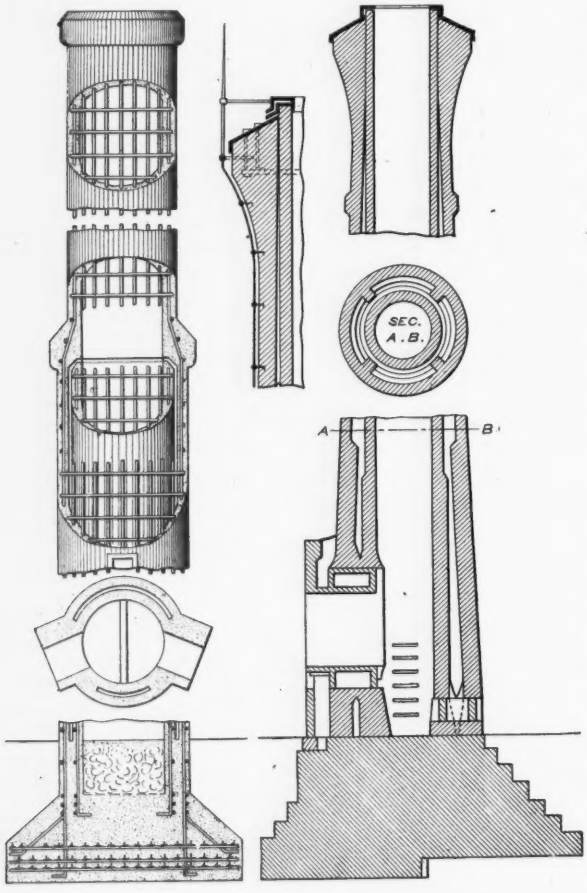


FIG. 3. SECTION OF CONCRETE CHIMNEY
FIG. 4. DOUBLE SHELL BRICK STACK

lected; like guyed steel stacks, they are liable to deterioration, due to the action of the flue gases, unless they are lined for their entire height. The bottom of the chimney is usually flared in order to secure greater stiffness. The height of the flare should be from 1.5 to 2 times the normal diameter of the stack, and the diameter of the flare at the bottom should equal its height.

Self-supporting stacks as a rule are provided with a cast-iron base plate through which the foundation anchor bolts pass. The minimum thickness of shell for self-supporting steel stacks should not be less than ⅜ in. H. C. Meyer, Jr., in "Steam Power Plants" quotes a rule for determining the strength of shell which has found considerable application. The required strength of shell being known, the thickness of plate may then be assigned. The rule is as follows:

Square the diameter, expressed in inches, and multiply by 0.7854. Divide the wind moment in inch-pounds by the above product and the quotient will be the stress per lineal inch.

The safe working stress should be reduced by the efficiency of the riveted joint. Linings for self-supporting steel chimneys may be made either continuous or in sections. A continuous lining should be made of sufficient thickness at the bottom to safely carry its entire weight. It should be at least 4 in. thick for the top 30 or 35 ft. and for each 30 ft. below should be increased by about 2 in. These proportions may be deviated from by calculating the weight of the lining and making the thickness proportional to the crushing strength of the material. Sectional linings should be 4 or 4.5 in. thick and supported at intervals of from 25 to 30 ft. by means of angle iron rings riveted to the inside of the shell.

Where the temperatures are not greater than 600 or 700 deg. F., common red brick will be found adequate as a lining material, although in good practice fire brick is used for a distance of 20 or 25 ft. above the top of the flue opening. When higher temperatures are expected fire brick should be used throughout.

Concrete Chimneys

Within the last decade, reinforced concrete has been applied to chimney constructions; the reinforcing is used vertically to take up the tension. These chimneys are usually built in two sections, the upper one being of single thickness. The thickness of the upper section is made 4 in. or more, depending upon the size of the chimney. The lower section is of double construction, the outer shell being 6 in. or more thick, while the inner shell is usually 4 in. An air space is provided between the two shells; this is generally 2 in.

The vertical reinforcing is carried down and anchored into the foundation so that the tension caused by the wind pressure is transmitted to the foundation and opposed by its weight.

Masonry Chimneys

Masonry chimneys are constructed of stone, common straight brick and of a special radial brick. Often times two and sometimes all of these materials are used in the construction of the same chimney. Stone is very seldom used as a material for the entire chimney, but not infrequently it is used to face the lower portion or base and for ornamental corbels, belt courses and caps.

Chimneys built of common straight brick may be square, octagonal or circular in cross-section for the entire height, or the lower portion or base may be square or octagonal with the upper portion circular. Large power plant chimneys are very seldom built square or octagonal for their entire height, as the cost is usually greater than that of a circular chimney and the efficiency less.

Chimneys built of common brick should be of double shell construction; the outer shell should be designed to withstand the wind pressure while the inner shell or lining must withstand both the influence and temperature of the flue gases. The shells should be entirely independent of each other and separated by a continuous air space throughout the entire height to allow for the free expansion of the inner core. The inner core may be made as thin as is consistent with the proper compressive strength. In order to keep it central with the outer shell, either buttresses may be built out from it to within a half inch of the shell and spaced at regular intervals around the circumference, or pilasters may be brought out from the shell to within a half inch of the core. The weight of the core does not enter into the calculation for the stability of the outer shell.

Thickness of Wall

A chimney should be designed so that there will not be a dangerous amount of tension on the windward side under the maximum wind pressure. If this condition is fulfilled and if the compression on the leeward side does not exceed the safe crushing strength of the material, the chimney is stable. To comply with these conditions the wall thickness is increased from a minimum at the top to a maximum at the bottom and the exterior is given a taper or batter. The wall is usually constructed in a series of sections, each section being of uniform thickness throughout its height. The thickness is increased in each successive section from the top to the bottom, the amount of the increase depending on the requirements for stability; the thickness of the top section may be computed from the following empirical rule by Professor Lang:

Thickness of top section in feet equals 0.328 plus 0.05 times the inside top radius of the chimney in feet plus 0.0005 times the height of chimney in feet.*

In any case the minimum thickness should not be less than 0.58 ft. for a chimney built of radial block, and 0.70 ft. for a chimney built of common brick. The batter is usually straight, although for architectural purposes it may be convex so as to present a graceful and pleasing appearance. The batter ranges from 1.7 per cent to as high as 3 per cent on a side. With a 3 per cent batter, the diameter would increase 6 ft. for every 100 ft. of height. An average good batter is 2 per cent for chimneys of normal proportions.

Stability of Stack

Knowing the height, the inside diameter, the thickness of the top section and the batter on the outside, a circular chimney which will be stable may be designed from the following rule:

Consider the chimney as the frustrum of a cone. Compute the volume of the chimney and from it subtract the volume of the flue. This will give the volume of the masonry. Multiply the volume of the masonry, which should be in cubic feet, by the weight of 1 cu. ft. of masonry in pounds and divide the product obtained by the equivalent total wind pressure in pounds. If the result obtained should equal the height of the center of pressure above the base in feet divided by the sum of one-half of the outside bottom radius and one-quarter of the inside bottom radius, the chimney will be perfectly stable.*

To find the volume of the frustrum of a cone, square the bottom radius, also square the top radius. Add the squares and to their sum add the product of the bottom and top radius. Multiply this final sum by 1.0472 and the height of the frustrum.

The only unknown factor in the above rule is the inside bottom radius, which may be found by substituting the known quantities and solving. Then having the thickness at the top and at the bottom, the chimney may be divided into sections and the intermediate wall thickness allotted. If any doubt is entertained as to the stability of the chimney at intermediate points, its stability may be calculated from the same rule. The tension or compression at any bed joint may be calculated from the following rules:

To find the pressure on the windward side, multiply the wind moment by the distance across the section considered and divide the product by 2 times the moment of inertia of the section. Subtract this quotient from the quotient obtained by dividing the actual weight above the section considered by the actual area of the section.†

To find the pressure on the leeward side, add the two quotients in the above rule instead of subtracting.‡

A tension greater than 2 tons per square foot is rather dangerous in any kind of masonry. It is a good rule not to allow more than 1.5 tons. The amount of compression varies between wide limits and is dependent upon the quality of the brick and mortar used.

---

* $t = 0.328 + 0.05\ r_t + 0.0005\ H$

Here t equals thickness of top section in ft., rt equals inside radius at top of chimney in ft. and H equals height of chimney in ft.

* $$\frac{1.0472\ d\ H\left[\left(R_t^2 + R_t\ R_b + R_b^2\right) - \left(r_t^2 + r_t\ r_b + r_b^2\right)\right]}{P} = \frac{h}{\frac{1}{2}R_b + \frac{1}{4}R_b}$$

In this formula d equals weight of 1 cu. ft. of masonry in lb.; H equals height of chimney above base, in ft.; Rb equals outside radius at the bottom; Rt equals outside radius at the top; rt equals inside radius at the top; rb equals inside radius at the bottom; h equals height of center of pressure above base, in ft.; P equals equivalent total wind pressure, in lb.

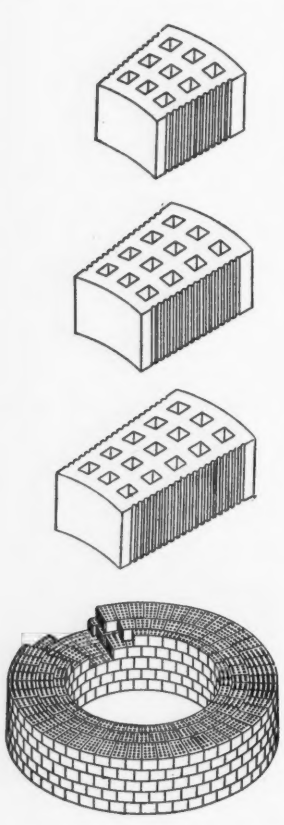
† $$\text{Pressure on Windward Side} = \frac{W}{S} - \frac{M\,l}{2\,I}$$

‡ $$\text{Pressure on Leeward Side} = \frac{W}{S} + \frac{M\,l}{2\,I}$$

Here W equals actual weight above the section considered, S equals the actual area of section considered, M equals wind moment, l equals distance across the section considered, and I the moment of inertia of the section considered.

Construction Detail

For architectural or mechanical reasons it may be found desirable to build a chimney with a circular shaft and octagonal or square base. The spread of the base may be computed in the same manner as the diameter at the bottom of a circular chimney would be. The base is usually built plumb both outside and inside; the flue is circular and usually the same diameter throughout as the inside diameter at the foot of the column. When a square or octagonal base is



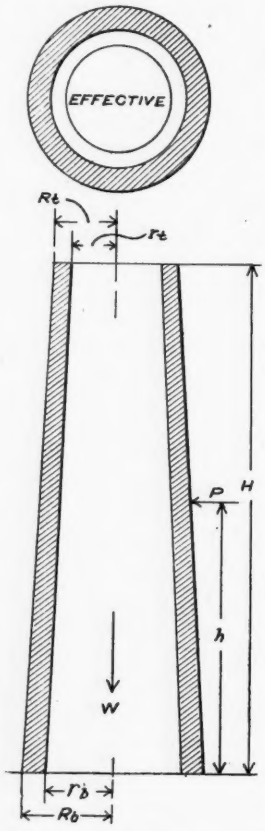


FIG. 5. RADIAL BRICK USED IN CHIMNEYS

FIG. 6. DIAGRAMMATIC SKETCH OF CHIMNEY SHOWING REFERENCE LETTERS

used, it is seldom necessary to figure for stability at the bottom of the base. The weakest point in such a chimney usually proves to be at the joint between the column and the base.

The top of the base is often racked out to form a cornice or capital, the top of which is finished off with a cement water table. It is customary to rack out at the bottom also to form a plinth, which, in addition to lending a graceful appearance to the stack, increases its strength. The height of a well proportioned base is about 1-5 the total height of the stack.

The base is invariably built of common brick, while the circular shaft above may be built of either common brick or a special radial brick. The latter type of brick offers several advantages over common brick for building a circular shaft, as the bricks are laid to a radius and the joints they form are uniform throughout. They are perforated vertically, which permits of a thorough burning and also adds to the strength of the bond, as the mortar is forced into the perforations, and thoroughly locks the courses together.

Radial bricks are usually made of clay having a high refractory quality so that unless exceedingly high temperatures are encountered, a fire brick lining is unnecessary. A single shell construction may be used where radial bricks are employed for temperatures up to 800 deg. F. The flue openings should have an area 20 per cent greater than the area of the stack at the top. If two or more flue openings are used it is necessary to locate them symmetrically so that the strains will be evenly distributed in the base. Where only one flue opening is used, it is very good practice to provide a relieving arch in the side opposite the flue opening so that the strains will be evenly distributed. The reveals of the flue openings should be faced with refractory brick to protect the masonry of the base from the incoming gases.

Where a common brick base is used the same is always lined with a refractory brick, either radial brick or fire brick. The lining is started on a corbel, 2 ft. below the bottom of the flue opening and carried to the top of the base or higher as conditions may seem to warrant. The lining is provided with an air space to allow for its free expansion. This air space should be at least 2 in. Where there are two or more flue openings in a chimney it is necessary to build a baffle wall to separate them to obviate the possibility of any back drafts. This baffle wall is usually constructed of fire brick and should be carried up above the top of the highest flue opening for a distance of at least 6 or 8 ft.

A clean-out door should always be built in the bottom of the stack to allow for free access to the interior. A clean-out door of cast iron answers very well. The same should be provided with a frame and latch, and unless the face of the jamb is very even, a gasket should be used to prevent air leakage. The clean-out door should be at least 20 in. wide and from 24 to 30 in. high.

The top of the chimney should be provided with a metal cap. Cast iron makes a good material for the cap, if it is made thick enough and thoroughly painted before being set in position. The cap may be cast in sections and provided with bolt holes so that it can be hoisted to the top of the chimney, assembled and rigidly bolted in place. The caps should be thoroughly bedded in a full mortar joint. The cap should be provided with flanges both inside and out so that it will lock the top courses in. For appearance sake the top of the chimney should be expanded into an attractive form of head, the contour of which may be either straight or concave. Where radial bricks are used it is possible by means of specially prepared

block of different colors to work out a pattern of fancy design in the head of the chimney, which adds to the appearance considerably. Often times by this same means it is possible to work in the name of the concern down the side of the chimney for advertising purposes.

Lightning Protection

For a masonry chimney a lightning rod is a very cheap form of insurance. The lightning rod, Fig. 4, should consist of a number of points to fully protect the top of the chimney. The points should extend 6 or 8 ft. above the cap. They should be made from copper of a high conductivity and the ends should be provided with platinum tips to insure their remaining sharp and bright. The tips should be at least 1.5 in. long. The points should be connected at their lower ends to a loop of copper cable, extending around the chimney just under the head. The cable should be of ample cross sectional area. For small sized chimneys one cable 7-16 in. thick is sufficient to serve 2 points; for larger chimneys 2 cables should be used to serve 4 or 6 points; the points should be clamped and soldered to the loop to provide adequate contact area. The loop should be thoroughly spliced into the vertical cables and soldered also. The vertical cables should be anchored to the chimney at intervals of 7 to 8 ft. by means of either copper or brass clamps bedded in the masonry, and so constructed that each will support its section of cable and in addition allow for any expansion in the chimney.

A ground plate should be provided for each cable, the same to be buried at a distance from the chimney of at least 10 ft. in soil which is permanently wet, or in a mass of powdered charcoal.

A ladder is invariably provided either on the inside or outside of the chimney. When the ladder is internal it may be constructed of U-shaped round iron rings imbedded in the masonry at vertical intervals of 16 or 18 in. It is good policy to galvanize the step irons so that they will more successfully resist the action of the flue gases.

Foundations and the Bearing Power of Soils

In laying out the foundations for a chimney, the nature of the soil should be very carefully investigated; a conservative estimate of the bearing value should always be used rather than an extreme one, as the stability and even the very life of the chimney depends upon the efficiency of the foundations. If there is any uncertainty as to the nature of the soil, test borings should be carefully made to a depth of 8 or 10 ft. below the bottom of the foundation, and the samples closely scrutinized. The borings should be so distributed as to establish without a doubt the character of the soil under all parts of the foundation.

Professor Baker, of the University of Illinois, gives the following bearing values for various subsoils:

Quick sand, alluvial soils, etc., ½ to 1 ton per sq. ft.
Clean dry sand, 2 to 4 tons per sq. ft.
Compact, well cemented sand, 4 to 6 tons per sq. ft.
Soft clay, 1 to 2 ton per sq. ft.
Clay on thick beds extremely dry, 2 to 4 tons per sq. ft.
Clay on thick beds always dry, 4 to 6 tons per sq. ft.
Rock equal to poor brick masonry, 5 to 10 tons per sq. ft.
Rock equal to best brick masonry, 15 to 20 tons per sq. ft.
Rock equal to the best Ashlar masonry, 25 to 30 tons per sq. ft.
Rock hardest in thick layers in natural bed, 200 tons per sq. ft. or practically unlimited.

From his experience the author is inclined to think that some of these values are a little too high, especially for chimney practice.

In most cases where the bearing power of the soil is less than say 1.5 tons per square foot, it probably will be found necessary to use piles.

Self-supporting steel and concrete chimneys from the nature of their design are subject to a positive tension on the windward side. Foundations for these types, therefore, must be so designed as to over-weigh any tension that the most extreme wind pressure may cause. The usual practice is to make the foundation one solid mass of concrete, reinforced if necessary, so as to be monolithic. The chimney is then anchored securely to the foundation and is integral with it. The tension is transferred from the chimney to the foundation and counterbalanced by the weight of its windward side and whatever back fill of earth there may be above.

Foundations for brick chimneys are never required to resist tension. The compression on the extreme leeward edge may be computed from the formula given for computing compression in the chimney itself. Concrete is the chief material which is used in foundations for brick chimneys at the present time. It should be made of a mixture of 1 part good Portland cement, 2.5 parts clean, sharp sand and 5 parts of aggregate, either gravel or trap rock.

The concrete should be well mixed and poured very wet so as to require no tamping. It should be put down in layers not greater than 8 in. thick. The angle of repose for concrete is about 45 deg.; the sides of the foundations, therefore, should be shaped at a 45-deg. angle. Foundations of square and octagonal cross-section are the most common, and are usually built in a series of steps, as the forms are more easily so constructed than for foundations that have straight sloping sides. The saving in the cost of forms more than offsets the cost of what little excess concrete is needed.

To FIND the diameter of a driven pulley, multiply the width in inches by 45 and the product by the velocity in feet per minute and divide by 33,000. The quotient will be the horsepower.

ELECTRICAL MACHINERY AND APPARATUS

RHEOSTATS FOR DYNAMO TESTING

By Jacob Glogau

IN NEARLY all electric plants full-load tests are made from time to time, and generally when these tests are made it is not possible to use the regular working circuits. The apparatus which is used to

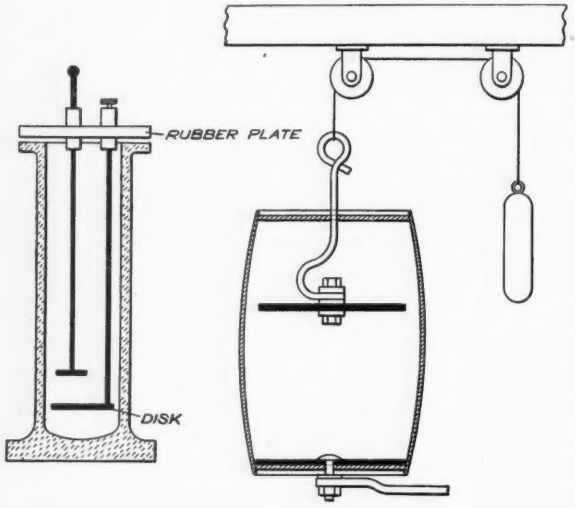


FIG. 1. RHEOSTAT GOOD FOR 20 AMP.
FIG. 2. ORDINARY BARREL RHEOSTAT

make these tests is known as the water rheostat. A water rheostat is a very handy piece of apparatus around an electric plant, although it gives a good deal of trouble at times. If handled carefully this trouble will be eliminated.

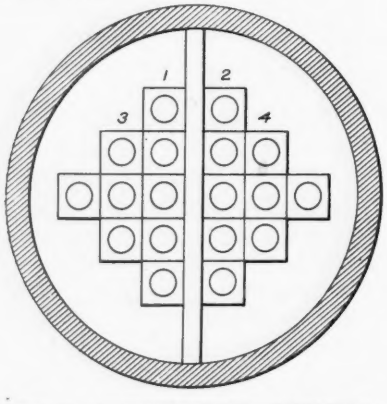


FIG. 3. SUBMERGED COIL RHEOSTAT

In testing small apparatus the form of water rheostat shown in Fig. 1 is generally used. This consists of a large glass jar with a rubber-cover piece on the top containing 2 binding posts for the connections. One binding post is connected to a piece of wire which goes down to the bottom of the jar and fastens to a copper disk. The other terminal is connected to a movable rod. The liquid used is water mixed with a few drops of sulphuric acid. This form of rheostat will stand about 20 amp., the jar being about 14 in. long by 3-in. diameter.

In the ordinary electric plant this form would not do, so a form of rheostat is used which is generally made out of an oil barrel, but practically constructed on the same principle. Fig. 2 shows this form of rheostat. Water is used in this apparatus and mixed with a solution of salt or sal-ammoniac. This rheostat has a capacity of about 100 amp., the barrel holding about 40 gal. of water.

One of the defects in water rheostats is the heating of the water after the rheostat is in use a short while. This heating effect can be done away with by introducing a series of pipes in the rheostat which have cold water running through them. When this form is used a tank is employed with the rheostat attachment on one side of the tank and the pipes on

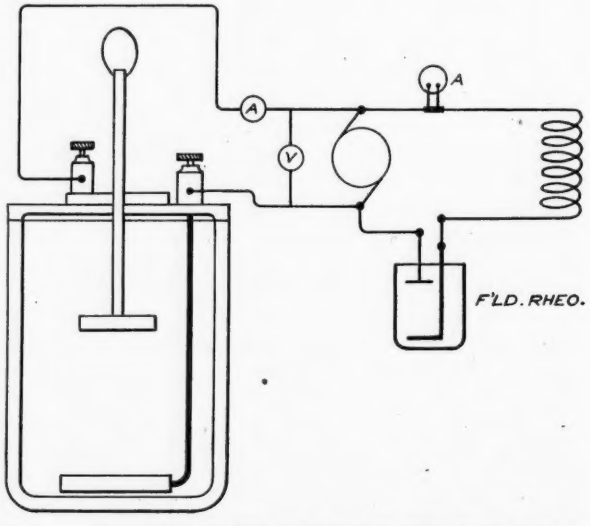


FIG. 4. CONNECTIONS FOR EFFICIENCY TEST WITH RHEOSTAT CARRYING FULL LOAD

the other. The pipes should be of copper as it is a good conductor of heat.

Another form of rheostat, known as the submerged rheostat, gives more constant resistance than any of the other types. The rheostat is made up of a certain

number of coils of iron wire placed in wooden compartments, one coil generally taking up two compartments, half in each. The compartments are placed in a barrel of water. Figure 3 shows the top of a submerged rheostat. Compartment 1 is connected with compartment 2, 3 with 4 and so on. The form of rheostat as shown in Fig. 3 will stand from 500 to 1000 amp. The dimensions are as follows: The diameter of the coils should be about 1.5 in., 2/3 of the coils should be about 75 ft. long—using No. 14 B. & S. gage; the remaining coils on an average of about 70 ft. of No. 16 and 18 B. & S. gage. When in use the coils may be connected in series, parallel or series-parallel. The capacity of the barrel is about 40 gal. When using this form of rheostat it is best to have the water changing at all times so as to maintain a constant temperature. Figure 4 will illustrate how a rheostat can be used in connection with a dynamo test.

IMPROVING A LIGHTING SYSTEM AT SMALL COST

By H. H. Yates

WHEN the writer took charge of his present position the lighting system was in the following condition: Current was supplied during the day, while the engine was running, by an 8.5-kw. Edison bipolar dynamo, generating 110 v. at 1,700 r. p. m., and driven by belts and countershaft from the main line shaft; at night current was obtained from the mains of the public service corporation.

The dynamo was about 300 ft. from the engine room in a room some years before used as an engine room, and when the new engine room was built and new engine installed, the dynamo was left in its old position.

An ammeter and ground detector, but no voltmeter, was placed near the dynamo, the rheostat being in the new engine room. The distributing switches, which for reasons unknown to the writer, were placed in the main office, consisted of one double-throw of 150 amp. capacity, one 100 amp. and one 75 amp. single-throw switch.

On the alternating-current line in the basement was the wattmeter and a 150-amp. switch, all switches being protected by open fuses, which occasionally would blow out, the resulting fireworks relieving the monotony of office work. Figure 1 shows diagrammically the arrangement of the switches.

Switch A was always closed. Up to the capacity of the dynamo C was open, B connected to the direct-current side and D closed the whole factory, being then supplied by the dynamo, through the wires designated "from dynamo and lower shops." Current was taken from this line for lighting the lower shops and supplying the magnets used in the manufacturing process.

The decorating shop was supplied through the switch B, and the upper shops by D. When the load exceeded the capacity of the dynamo, usually about 4 p. m., during the winter months, D would be opened and C closed, throwing the upper shops on the alternating current, but taking off more load than necessary, this circuit being comparatively large. Then just before stopping the engine at night it was necessary to again go to the office and throw all the switches, so as to put all but one of the circuits, that of the lower shops, on the alternating current.

In case light was needed in the lower shops at night, it was necessary for one man to go to the dynamo and one to the office. As soon as the switch at the dynamo was opened, those in the office had to be quickly changed, as the whole place was in darkness. This was both inconvenient and dangerous for the workmen. It was also possible to get, through C and D, alternating and direct current together, with the usual fireworks.

Another bad feature about this arrangement was that when it was necessary to stop or slow down the engine, all the lights would go out, interfering greatly with the work, it being impractical to go to the office to change the switches.

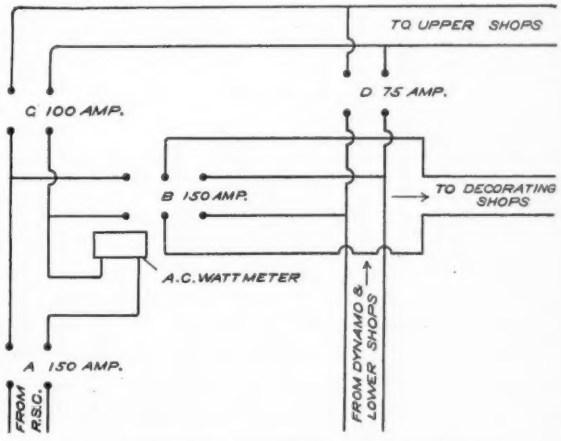


FIG. 1. SKETCH OF OLD SWITCH ARRANGEMENT

The old dynamo becoming worn out, it was decided to install a larger one, and after some argument on the part of the writer the machine was placed in the engine room, although it was rather difficult to find a place for it. This difficulty, however, was overcome by tearing down a large built-in closet in the rear of the engine, through the lower part of which the main shaft ran. Permission was also secured to remove switches from the office and erect a switchboard, the writer agreeing to keep the cost as low as possible, construct the board and change necessary wires.

The new machine was a 20 kw., 4-pole Thresher, compound wound, generating 110 v. at 700 r. p. m., and was placed nearly back of the engine cylinder, about 5 ft. from the end wall of the room, and about 2 ft. from the main line shaft. The rails were bolted to stringers which were bolted through the concrete floor, the machine placed, wall brackets bolted to the end wall of room, all aligned with main shaft and temporary wires run from the old main supply wires.

Next day, as soon as direct current could be spared, about 4 p. m., and the lights thrown on the alternating circuit, the old machine was stopped, the countershaft removed to engine room, old pulleys taken off and new ones of proper size put on, and put in its position on the wall brackets. The driving pulley was then lined up on the main shaft and the belts put on. The temporary wires were connected to the machine, the meters and rheostat, etc., fastened temporarily to the wall, and by 8:30 p. m. the new machine was supplying the building with current,only 4½ hr. being required for the change.

As soon as possible a piece of slate, 36 by 60 by 1½ in., was secured, and sufficient 1½ in. angle iron

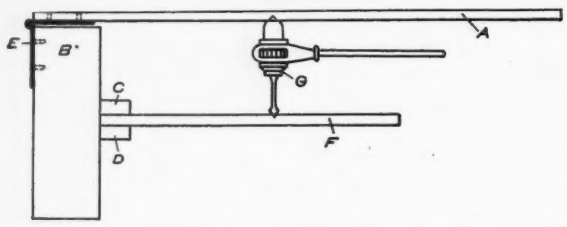


FIG. 2. METHOD OF DRILLING SLATE PANEL

for framework was ordered. When finished the board was 6 ft. high, 1 ft. from the floor and 15 in. from the wall. The holes for bolts to support the voltmeter and ammeter, rheostat, alternating-current wattmeter, ground detector, etc., were laid out and drilled, one at a time. The switches were removed from their old position and fastened to the board, this proceeding making it necessary to wire across the space they occupied, which some may question, but it was the only thing possible, as it was imperative that light should not be interfered with.

As the switches had been mounted on ⅝-in. slabs, and were not designed for a board, it was necessary to countersink the holes on the back of the board, also to bring the wires through holes, both above and below the switch. Some might say that proper switches should have been secured, but the management would not stand for it, so it was necessary to do with material on hand, the only new switch being for 35 amp.

With the exception of the two small ones, all circuits are protected by enclosed fuses. Above each switch is a porcelain plate, showing the building supplied. Above the switches are the voltmeter and ammeter, the pilot light, which serves to illuminate the dials, and the ground detector; below them the double-throw switch, the left side being alternating, the right direct current, and at the bottom the wattmeter and rheostat wheel.

The bus bars are made of heavy copper rods, and are fastened to the board by bending the ends at right angles, and after upsetting the ends, are cemented in holes drilled in the slate, making a very rigid connection. All wires are wrapped around and then soldered to the bars.

By taking advantage of odd minutes, and making preparations in advance, the change from one system to the other was made without interrupting the work of the factory in the least, and although part of the old equipment had been used, and 1100 ft. of No. 4, and 300 ft. of No. 00 wire strung, the machine set and board constructed, the total time required was only 5 weeks, but about 12 hr. of that time was after regular hours. The small holes in the slate were drilled with a carpenter's brace and bit; the larger ones with a ratchet, the latter being used with a rig which might be helpful to someone, so a sketch of it is given here: A is a piece of yellow pine, 1 in. thick, 5 in. wide and 5 ft. long; B a piece of 3 by 4 in., about 15 in. long; C and D, strong blocks, far enough apart to accommodate material to be drilled; E, a strong strap hinge; F, the material to be drilled, and G, the ratchet drill. By having an assistant press or sit on the end of A, holes can be drilled in quite hard material.

The switchboard, while not elaborate, will compare favorably with that of many small plants, and the total cost of new material did not reach $20.

NOVEL USE OF ELECTRIC FLAT IRONS

It is not often that heating units from electric flat irons are put to as severe a test as in the instance given below. The problem was to replace a crank pin on the high pressure side of a 500-h. p. cross compound Russell engine. The new pin was 6 in. in diameter with a taper of 1/64 in., and had to be fitted tight into the disk, which was 5 in. thick, with a 12 in. shaft. To expand the disk by heating it with blow torches would have taken too long, besides making a dirty and unsatisfactory job, so several heating units from General Electric 6-lb. flat irons were grouped around an iron core, 3¾ in. in diameter, and placed in the 6-in. hole in the crank disk. In 4 hr. after the current was turned on the disk had expanded sufficiently to allow the crank pin to slip in. Although the heating units were at about white heat all of the time, they were not injured except that the brass tubing on two was slightly melted in one place. The heating units were replaced in the flat irons and have been in use for the last 3 months, one of them being in a laundry, where their active service averages 40 hr. each week.

IT IS CLAIMED that the British navy is ahead of all rivals in the matter of wireless telegraphy.

INTERPOLE RAILWAY GENERATORS

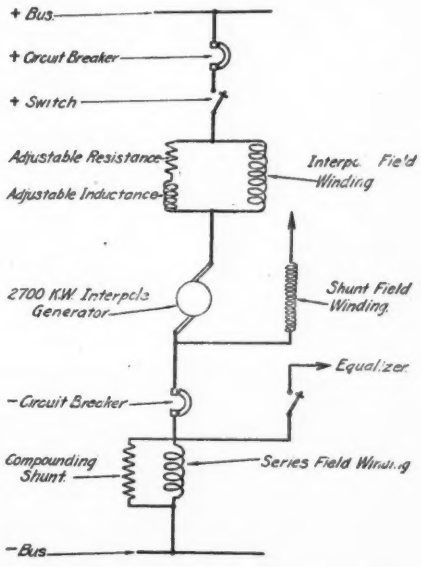
DESIGN, CONNECTIONS AND TEST OF A GENERATOR BUILT TO PREVENT SPARKING

THE function of the interpole generator briefly stated, is to neutralize the armature reaction and to assist in changing the direction of flow of current in the short-circuited coil under commutation by creating a flux in the opposite direction and somewhat larger than that due to the armature current. By keeping the interpole below saturation and exciting it by a series winding, it is evident that its action may be approximately proportional to the load on the generator. The result is good commutation over a wide range of loads without change in the position of the brushes.

Two 2700 kw. railway generators of the interpole type have recently been put in the Charlestown and Harvard power stations of the Boston Elevated Railway Co. One of these generators has now been in operation about 5 months and some results of its construction and operation are given by a writer in the Public Service Journal. In explaining the principle upon which it works, it is shown the exact flux required in the interpole field would often demand series turns on the pole of a number difficult to build as, for example, 2⅜ turns. The remedy for this difficulty first tried was to make the number of turns on the interpole larger than necessary and shunt out part of the full series current by a noninductive shunt connected at the terminals of the interpole winding. On sudden variations of load, however, the current changed relatively more quickly in the shunt than in the interpole circuit, and the interpole failed to do its duty just when it was needed. The next step, which met with full success, was to make the shunt inductive instead of noninductive. This inductive shunt is used on the Boston elevated generators, the diagram of its connections being shown in the accompanying sketch. Inasmuch as these generators were the first interpolars of their capacity to be built, they were designed to obtain considerable adjustment of the interpole connections. The interpole winding has 2½ turns and a tap at two turns. The resistance and inductance of the interpole shunt are also adjustable.

Complete tests were made to determine the best adjustment of the interpole connections and the full load and overload temperature rise. Load for the test was obtained by the use of a water box rheostat. Thirteen boxes about 16 in. wide by 24 in. deep by 10 ft. long were constructed. A row of 14 cast-iron grid resistances, each of approximately 0.083 ohms resistance, were connected in series and immersed in a water box. Five hundred to 600 amp. were obtained on each row of grids connected across 600 v. The heat generated was dissipated by permitting a continuous stream of fresh water to flow through the box. The result of the tests showed the best adjustment of the interpole conections was 2½ turns on the interpole winding, with the inductive shunt set to shunt out about 16 per cent of the series current from the interpole winding. The heat tests developed a rise in temperature after a full load run of 24 hr. of 20 deg. maximum above room temperature, which occurred in the interpole field. The 2 hr.'s run at 50 per cent. overload immediately following full load run, gave a further rise of 15 deg. maximum in the interpole field. The circuit breaker was tripped repeatedly on loads up to 50 per cent overload without the slightest sparking at the commutator and no tendency to flash over was evident.

Five months' operation of one of these generators give good evidence of the reliability of the design.



CONNECTIONS OF INTERPOLE RAILWAY GENERATOR

The interpole machines have been operated in parallel with machines of equal and smaller capacity of the noninterpole type with entire satisfaction. Although a large saving in weight has been effected in the new type, the machine is capable of giving superior results with the minimum of operating worry. This superiority consists principally in the decrease in brush and commutator troubles caused by sparking, the absence of any necessity of shifting brushes with load changes (brush mechanism is locked in place), and the decrease in danger of injury to operators and machines incident to flash-overs.

THE BOILING POINT of ammonia under atmospheric pressure is 28.5 deg. F. below 0, instead of 40 deg. as stated on page 11 of the March issue.

REFRIGERATING EQUIPMENT AT MARSHALL FIELD'S

MODERN ABSORPTION SYSTEM AS APPLIED TO A GREAT RETAIL ESTABLISHMENT

RESOURCES of the mechanical arts are now being taxed to the utmost to supply the comforts and necessities of present day business institutions. Thus it is not surprising to find that refrigeration, which was once looked upon as a luxury, is now considered a necessity in the up-to-date department store, office building, or other similar establishments.

The firm of Marshall Field & Co., of Chicago, which is the fountain head of the great State Street retail trade, and whose plant occupies nearly the entire block bounded by State, Washington and Randolph Streets and Wabash Avenue in the loop district, has long made use of this medium as a comfort to its patrons and a necessity in the transaction of its business.

Originally, a compression plant consisting of two Newburgh horizontal, duplex, double acting ammonia compressors were used, driven by 75 h. p. electric motors and developing 40 tons refrigeration effect each.

As the business expanded and it became necessary to reconstruct the power plant and economize in

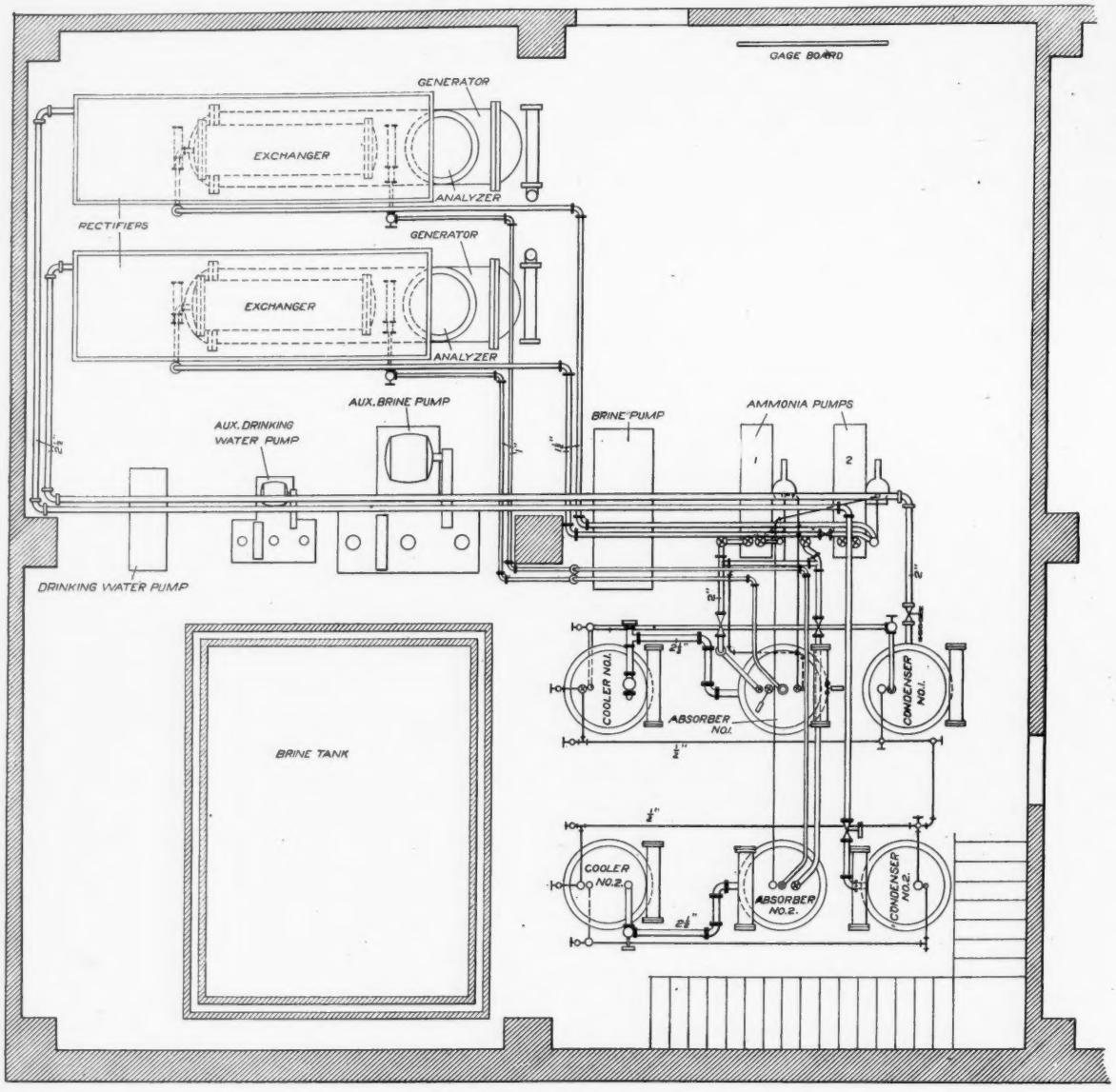


FIG. I. GENERAL ARRANGEMENT OF THE PLANT

space, a new location was decided upon for the refrigerating apparatus and 2 40-ton ammonia absorption machines, together with all auxiliaries, built by the Carbondale Machine Co., of Carbondale, Pa., were installed on the thirteenth floor of the East building. The considerations which led to the adoption of this

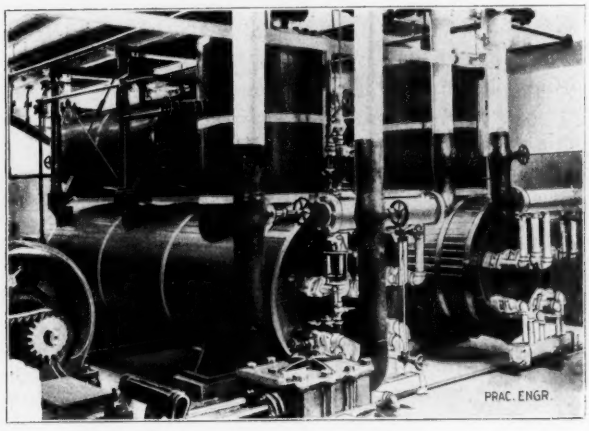


FIG. 2. GENERATING APPARATUS OF ABSORPTION SYSTEM

type of apparatus and its location were as follows: Less head to pump against on brine and drinking water systems, better light, better ventilation in case of leakage, balanced brine and drinking water systems, location allowing the use of domestic water for cooling purposes before being delivered to the house tanks.

As shown in Fig. 1, the entire plant is most compactly arranged, all apparatus being in the same room and conveniently located. The two generators are of the standard Carbondale construction, with a horizontal body or still containing the steam coil of 1.5-in. pipe.

Mounted vertically at one end is the analyzer and at the other the horizontal exchanger, the whole being lagged with hard wood with polished steel bands, presenting a neat and attractive appearance, which, by the way, is a characteristic of the entire plant, it being a credit alike to the company which installed it and the men who operate it.

Figure 2 illustrates the generator and shows also the rectifier pans located immediately above and through which circulates water from the absorber. From the analyzer the gases pass to the rectifier coil which consists of 5 3-in. pipes connected by return bends and in which the moisture is condensed. The return bends are tapped at the end farthest from the analyzer and the condensation is collected in a receiver, from where it passes back to the analyzer at a point midway between the top and bottom. From the rectifier coils the anhydrous gas passes to the condensers, where it is cooled by water from the city mains circulating through coils. The condensers also act as receivers, and the liquid anhydrous ammonia is passed through the expansion valves into the coolers as fast as needed.

Here the brine passing through the coils is cooled to an average temperature of 12 deg. F. before passing to the various cooling boxes located throughout the building. The expanded gas passes to the absorbers, which work on the empty principle, the weak liquor being sprayed from a nozzle in the upper part of the cylinder and coming into contact with the expanded gas, absorbing the latter and falling to the bottom of the absorber in the shape of rich liquor. The bottoms of the absorbers are provided with gage glasses to indicate the amount of rich liquor contained therein.

To remove the rich liquor, two steam driven ammonia pumps are provided 10 and 4½ by 10-in. in size, one for each absorber, controlled by float governors, removing the rich liquor as fast as the weak liquor flows in at the top. These pumps, together with their regulators, are shown in the illustration Fig. 3. Refrigeration is accomplished by the circulation of brine through a 9 and 8½ by 12-in. duplex Dean pump. A large brine storage capacity is provided, enabling the plant to be shut down at night and still maintain the low temperatures required by the circulation of the brine. For this night service, an auxiliary brine pump consisting of an 8 by 8-in. Gould triplex pump driven with Morse chain by a 4-pole Crocker-Wheeler motor is used, taking current at 220 v. from the outside wires of the 3-wire house service.

Chloride of calcium brine of 1.250 specific gravity is used in the system and commences its circuit ordinarily at a temperature of 25 deg. F., and during the day lowers to 0 deg. F., and is circulated all night with the plant shut down. Among the special features of interest in the plant may be mentioned:

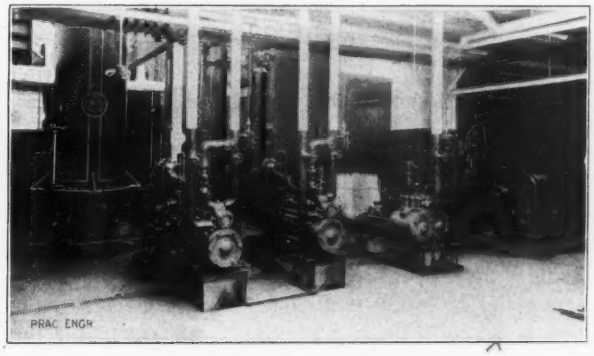


FIG. 3. AMMONIA AND BRINE PUMPS

First.—The ideal location of the plant as regards the highest efficiency of power required for the pumping of both brine and drinking water. Second.—The use of the domestic water for cooling in condenser, rectifier and absorbers before being re-used to supply the house tanks. Third.—The high efficiency obtainable in the use of exhaust steam from brine and drinking water pumps for the purpose of generating the ammonia gas.

An efficiency test of the plant recently run showed the following results: Approximately 39.6 lb. of

steam per ton of refrigeration and 1.65 gal. of water per ton of refrigeration.

Fur Vault

One of the most important services to which the refrigerating plant is put is the cooling of the fur vault located on the twelfth and thirteenth floors, and which is arranged for the storage of furs and fur garments. This vault is a single room 77 ft. long, 33 ft. wide and 26 ft. high, containing over 66,000 cu. ft. of storage space. It is extremely well insulated with

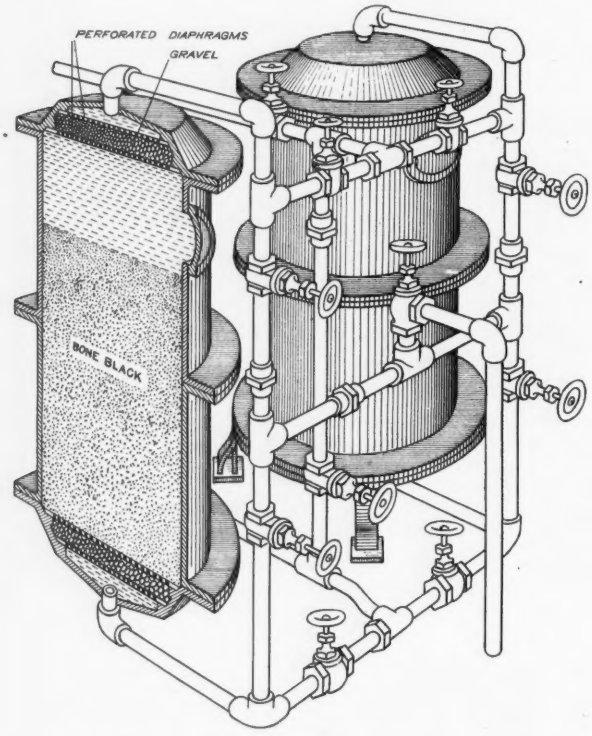


FIG. 4. THE CUMMINGS FILTER IN HALF SECTION

triple walls and is maintained at a temperature of 14 deg. F. the year round.

The air in the fur vault is kept in circulation by a 90-in. fan, driven by a Crocker-Wheeler motor, which changes the air every 8 to 15 min. In a separate chamber, 28 by 12 by 10 ft. in size, the air is forced over 2-in. brine coils, being cooled and returned to the fur vault through galvanized iron conduits extending along one end and on two sides near the ceiling.

When necessary to renew air in the vault, a new supply is taken through the roof through a conduit, and is filtered through cheese cloth before entering the cooling chamber. Two anterooms, 7½ by 6 by 9 ft., are provided as entrances, one at each end, and in each one drying boxes, containing calcium chloride, are used to guard against moisture getting access to the vault. The interior of the vault is conveniently arranged in tiers for the hanging of fur garments, and is lighted by electric lights, which can be turned off and on in sections.

In addition to the fur vault, the brine system is required to cool 18 separate refrigerator boxes located in the employes' lunch room, the public tea room, etc. The boxes are cooled by brine piping placed on the top and upper side walls of the enclosures.

Drinking Water Systems

This important service has been worked out in the greatest detail, to the end that nothing but the most wholesome water is supplied to the patrons of the establishment and its 7000 employes. Water coming from the city mains is first passed through a Cummings' filter, made by the Cummings' Filter Co. of Pittsburg, Pa., which equipment is shown in part section in Fig. 4. It is really two filters installed in duplicate, arranged to operate singly in series, or parallel, as required. The filter, which has a capacity of 2500 gal. per hour, consists of a cast-iron shell, with a pair of perforated galvanized iron diaphragms at the top and bottom, covered with brass wire gauze, serving to keep the filtering material in place. By manipulation of the valves, either of the filters may be washed with filtered water from the other without interrupting the supply. Bone black, or animal charcoal, is used as the filtering medium, and serves not only to clarify the water of its suspended impurities, but also to absorb objectionable gases by occlusion, according to the well-known action of charcoal on gases. After passing through the filter, the water goes to the drinking water supply tank, shown in Fig. 1, its flow being regulated by a float valve, maintaining a constant level.

This water is kept at a temperature of about 40 deg. F. by a Baudelot cooler, consisting of 2 coils of 2-in. copper pipe 12 ft. long and 24 in. high, through which the brine circulates in series. About 125 bbl. of drinking water per day are supplied to upwards of 85 different drinking water fountains, the lunch room, tea room, etc. Several times this amount is circulated, however, in order to keep the temperature at a required point, the excess being returned to the Baudelot cooler before again passing through the system. A 6 and 4 by 6-in. duplex Dean pump circulates the drinking water, with a 5 by 8-in. triplex geared Gould pump held in reserve and driven by a Crocker-Wheeler motor with chain drive.

Exhaust steam, at atmospheric pressure, from the brine and drinking water pumps, operates the generators, giving up its latent heat in the generator coils, the condensation being removed by Anderson traps. To provide for any deficiency of steam, a live steam connection is provided, the steam being reduced to atmospheric pressure through a 2.5-in. Kieley and a 2-in. Foster reducing valve, through which the steam passes to the generator supply piping.

THE EFFICIENCY for single riveted boiler seams is taken at 0.60, for double riveted 0.70 and for triple riveted, butt strapped joints, 0.875.

REPAIR KINKS

Stuffing Box Flange

When screwing some ⅞-in. studs into a stuffing box of a 12-in. double-acting pump, the flange of the gland broke. As the pump simply had to run, a temporary repair was made with a pair of clips and a

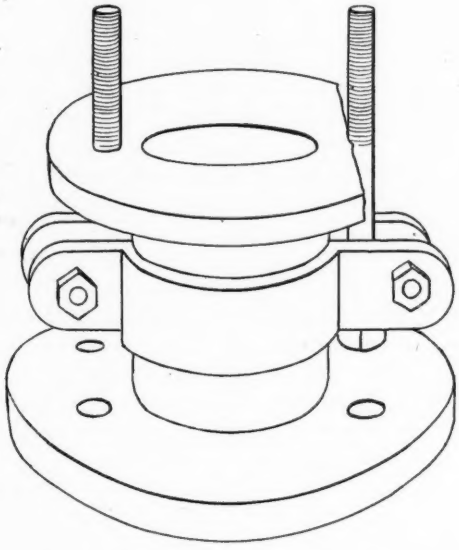


FIG. 1. BROKEN STUFFING BOX REPAIR

tee-head bolt, which, though not exactly artistic kept things going.

Withdrawing Keys

For this work, the tool illustrated herewith will be found convenient, and when used with a heavy hammer and suitable key drift, will start the most obstinate cases. The puller is a round bar with head

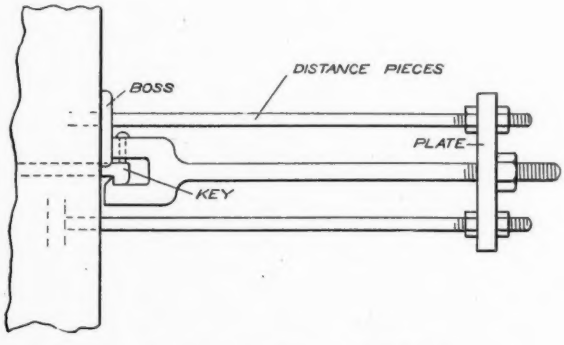


FIG. 2. AN EFFECTIVE KEY PULLER.

forged of suitable shape and fitted with a set screw to keep the bar in position on the key head. The plate may be flat, or better, a piece of channel iron to give rigidity. The distance pieces are round steel rods adjustable through the plate to bear against the shaft, the hub or a spoke as may be required. The sizes of parts should, of course, be proportioned to the size of the keys to be handled.

Silent Water Heating

For heating water by steam from an open pipe, the device of Fig. 3 will do away with the noise. It consists of a 1¼-in. tee A, and a piece of 1¼-in. pipe 6 in. long, B, having in the back of the tee a short piece, C, of ½-in. pipe 5 in. long, through which the steam enters. This apparatus should be set 1 in. or more from the bottom of the tank to allow of free circulation of the water through it.

For small tanks, a ⅜-in. steam nozzle may be used, but for very large tanks it is better to use 2 or 3 heaters than to make one of size larger than here given.

Economizer Repair

What looked like an impossibility was recently accomplished in the repair of a Green economizer branch pipe of 12 connections. The flange broke as indicated

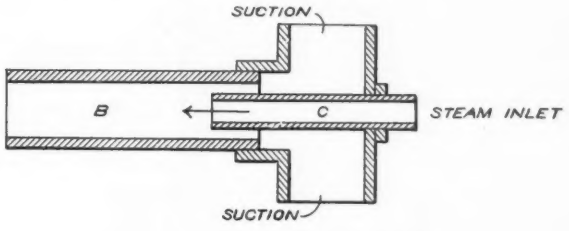


FIG. 3. A SILENT WATER HEATER

in Fig. 4, when remaking the joint after a blow out. Although the case seemed hopeless, a shut down was serious, so an iron hoop ⅞ by 0.5 in. was shrunk on tightly over the neck of the flange. While this job was cooling, the metal around the crack was chipped away, leaving a bright surface on the inside which was tinned over.

When coupled up the job stood 100 lb. pressure and is still running.

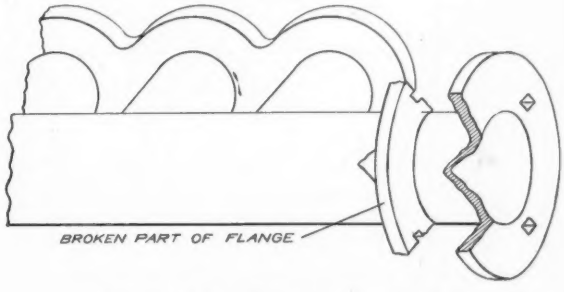


FIG. 4. BROKEN ECONOMIZER FLANGE

THE EFFICIENCY commonly obtained with steam boilers in the western states with bituminous coal is not over 60 per cent and is often less than 50. Probably 55 per cent is a fair average. Seventy-five per cent may be obtained with mechanical stokers and furnaces adapted to burn the volatile matter of the coal.

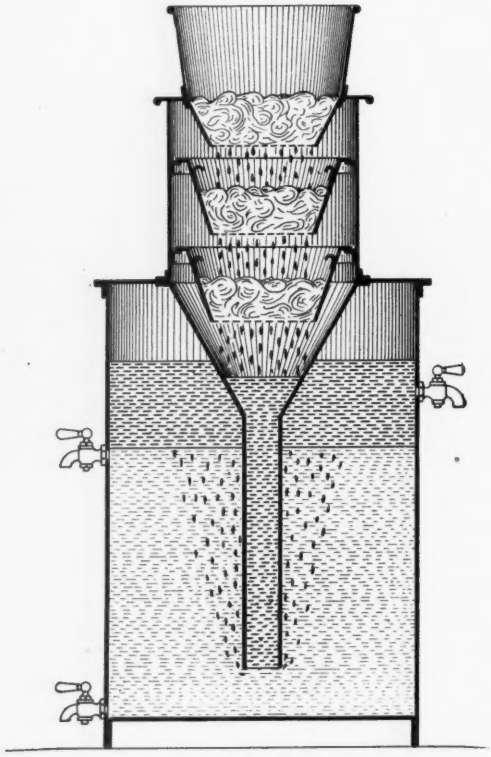
LETTERS FROM ENGINEERS

Send us descriptions of ways of doing new things, and new ways of doing old things. Rough pencil sketches and letters are all right; we will fix them up for the printer. All accepted contributions will be paid for when published.

A Homemade Oil Filter

Editor Practical Engineer:

A long time ago I was badly in need of an oil filter. Not knowing what to do at that time, I conceived an idea of my own and put it to work. First I made a filter out of the barrel that the oil came in. It was a crude affair and will not attempt to describe it here, as the barrel commenced to leak in about a year. My



SECTION THROUGH FILTER

next venture was a galvanized tank, as per sketch herewith. This was inexpensive to build, when you take into consideration the amount of saving it effected. The oil that it filtered is absolutely as clean and cleaner than when first used. There is no dirt or scale that can get into it, and, as everyone knows that uses oil, there is always sediment that comes from the inside of a barrel.

In the filter there are three pans, made out of galvanized iron, in the shape of a colander that our mothers use in the kitchen, but have fine brass wire screens instead of perforations for a bottom. The handles are placed on the inside instead of the outside, so as to make it convenient to lift each pan out separately. The top pan has a flaring top to it and is made large enough so that it will hold about a bucket of oil. I cover the bottoms of the pans about 2 or 3 in. with good waste. The wire bottom can be covered with cheese cloth if so desired. I did that, but do not think that is required, and do not use the cloth now. The waste can be cleaned by subjecting it to a steam scalding process, that is, putting it in a barrel or box or anything in fact, where it can be scalded out thoroughly. After it is pulled apart and dried, it is just as good as it was before for any purpose. The filter needs no attention, practically speaking, as the waste need not be changed but once a month, unless there is a considerable amount of oil to filter. We have about half a bucket a day.

By the cut it can be seen how the oil is filtered. The heavy substances are washed out of the oil in passing through the water, and fall to the bottom of the tank, where they lay until the tank is cleaned. The whole thing is made out of galvanized iron, and is very substantial. The top spigot is for drawing the filtered oil, the second or middle spigot is to maintain the water level and the bottom spigot is to draw off all the water. There can be a water gage glass and also one to see the oil if it is deemed necessary.

The filter can be made from the size of a gallon can to 50 or 100 gal. I have made three of them, the first about 20 yr. ago, when I was working at an electric light plant. In about a year after I built the filter, I left and did not hear or think about it again until I wanted one for our plant, this being about 3 months ago. Our firm installed a new engine that retains the oil, and we catch it the same as all other people do nowadays. I inquired about the filter I left years ago. The engineer said that he did not know who made it, but thought it an all right filter, as he had been using it ever since he had been there and it gave good results. So I set about and built myself one more and it has been running 2 months. It gives such good results that I want it to do for others who are in want of a good filter the same that it is doing for me.

Burlington, N. J. Jacob S. Woolman.

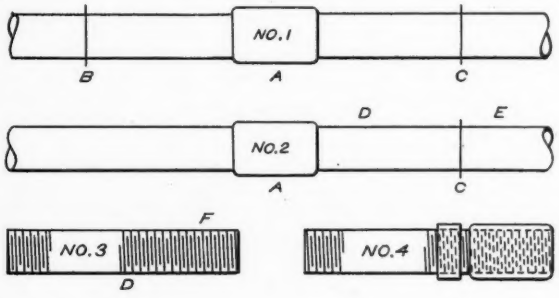
Repairing Leaky Pipes

Editor Practical Engineer:

If there is anything around a steam plant any more wasteful and unsightly and altogether disagreeable than a lot of leaky joints in the piping the writer has failed to notice it, and in nearly 20 yr. of practice as an

engineer he has failed to find anything more neglected.

This is due partly to neglect or lack of time on the part of the engineer, and in not a few cases, to the neglect or unwillingness on the part of the management to furnish proper fittings and supplies with which to make a quick repair. I will endeavor to show the merits of a fitting that I have found very convenient. While it is carried in stock in most steam-fitting supply houses, it is not commonly known to



METHOD OF REPAIRING LEAK

engineers, so that its value and adaptability is not appreciated as it deserves. The fitting I mean, is the long screw or Philadelphia union.

This useful article is very simple to make and use, and the materials for its manufacture are usually to be found in abundance in almost every engine or boiler room. It consists of, first, a body which can be made of short pieces of pipe, the diameter required, and of any length above 6 in., second, a coupling and a locknut or something for a substitute, such as one end of a coupling an inch long or such a matter.

Now, brother engineers, suppose you have a leaky coupling or a pinhole in a long run of pipe. There is no union near it, and in order to fix it you have to take down a lot of piping, and chances are, start more leaks in so doing. It takes a deal of time that you need for other work. Naturally, you would cut the pipe near that point where the leak is, and put in a union, but those unions cost money, and sometimes the old man won't furnish them. I have seen such cases. Now, here is a quick, easy way to fool him, and make good as a practical man.

Assume there is a joint at A, No. 1, in a long run of pipe, far removed from an end or union. The leak is caused by a crack in the coupling or the thread is wasted away, but the thread on the pipe itself is all right and whole. Take a pipe cutter or a hack saw and cut the pipe off at B or C, a foot or more from the coupling, or nearer, if you have a nipple holder. Now take out both pieces D and E, No. 2, and the coupling A.

At C cut a thread long enough to take on a whole coupling and a lock nut or substitute on piece E. Cut an ordinary thread that will leave D looking like No. 3. Next get a new coupling and put one in the place of the leaky one at A, and with a file, or better still, with a lathe, if you have one, square up one end of the other coupling, leaving it a very little concave. Now, if you have no locknut, take a cutter hack saw or whatever is most convenient, and cut off the good end of the coupling you had to replace, square it up and use it for a lock nut. Now turn it onto the long thread F, No. 3, as far as it will go. Next, take the coupling with the square end and turn it onto the long thread end until the other end is flush with the end of No. 3, and your union is complete and will look like No. 4.

Now put D back where it belongs, next turn short thread of your long screw union into the new coupling, where it belongs, bring the ends of D and E opposite each other and back the largest part of the D union off of D, at the same time turning it onto E as far as necessary to make E steam tight. Now get a few strands of valve stem packing and wrap around the unions as close as possible to the square end of the coupling, and back the locknut up to it as tight as possible and your joint is tight and will stay so as long as any joint in your plant. You have saved the company a dollar, made use of stock that would otherwise have been wasted and a dead loss to your employer, and have added no small bit to your reputation as an able and efficient engineer, such as are in demand right along. Now you have the idea, think it over and see what a number of different places it will fit in.

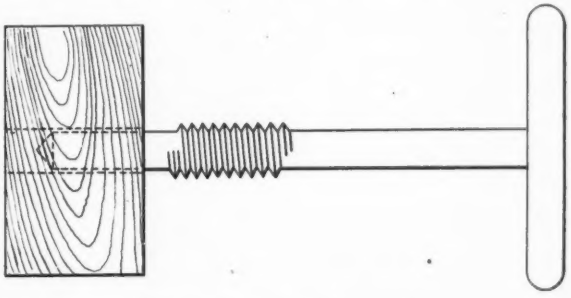
W. E Chandler.

Woodstock, N. H.

Soldering Tip of Water Gage Spindle

Editor Practical Engineer:

The accompanying illustration shows the method I use in soldering the tip of a water gage spindle or a sight feed spindle or drip valve. Take a 1-in. block and bore a hole through to make a tight fit on the



METHOD OF SOLDERING SPINDLE

spindle, then file end of spindle and dip in acid and adjust it in hole of block to have any desired thickness on tip, same as shown in the sketch. Melt a little soft metal and pour in the opposite side. File the end to fit the seat, and in a few minutes you will have a good tight seat. Should the valve seat be cut, it can be reseated with a drill by grinding it to any desired degree.

G. O.

Warming Cylinders

Editor Practical Engineer:

In reference to H. B.'s method for keeping the cylinder warm, I am inclined to think that connecting both ends of the cylinder with a pipe, as shown in his sketch, is bad practice. The tees on the drip pipe, at any rate should be placed above the valves, instead of below them. If these changes were made, and it was found that too much of the exhaust steam from pipe B escaped down the drip pipes, an extra valve could be placed on the drips below the tees. The two upper valves would have to be left open in any case when warming the cylinder with exhaust steam.

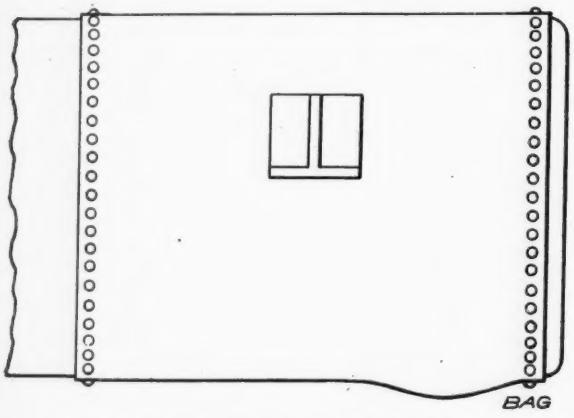
When an engine is located in an exposed position, and it is liable to be wanted in a hurry, some method of piping which will keep the steam pipe to the engine free of water must be used. On this account a small live steam pipe is usually taken from the main pipe, as close to the throttle valve as possible, in which case it answers the twofold purpose of draining the steam pipe and keeping the cylinder warm.

Toronto, Can. J. E. N.

Repairing Bag in Boiler

Editor Practical Engineer:

I have been reading about engineers' troubles in the Practical Engineer for some time, and I find them both interesting and instructive. I wish to write a few lines about the crown sheet of a boiler bagging and how I repaired it, as it may be of help to some other engineer having the same trouble. Some time ago I was called to look at a boiler which was bagged, and when I got there I found a boiler of 60 in. diameter



BAG IN CROWNSHEET OF BOILER

by 18 ft. long, carrying 80 lb. steam pressure. The boiler had bagged in the crown sheet about 12 in. from the front. The bag was about ½ in. deep and 8 to 11 in. long.

A bag in the crown sheet is generally repaired by cutting out the affected part and riveting a patch over it. To do this is sometimes an expensive and mean job, as frequently several of the tubes over the bag have to be taken out, requiring a shut-down of several days.

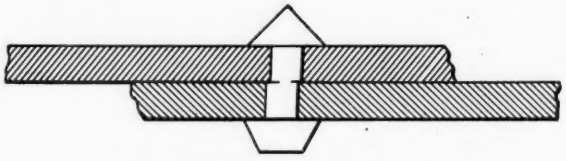
The first thing I did was to test the bag with a light hammer, and as it was not cracked or blistered in any way, I took 2 gasoline torches and raised the affected part to a red heat; then took a sledge and hammered the metal back to its original place. This method is safe as well as cheap, and it only took about 4½ hr. to do the job. If properly done the boiler will not be injured, and will stand inspection by any insurance inspector. L. R. Peiker.

W. Orange, N. J.

And Still We Wonder Why Boilers Explode

Editor Practical Engineer:

While looking over the remains of the late Harney explosion at Lynn, before the debris was cleared up, my attention was aroused by the sight of a long crack along the girth seam, which was rather a tear or rip, and of which there were several such rips in the different seams, each opening up enough so the rivets



RIVETS SHEARED 15 TO 20 PER CENT

could easily be knocked out. I picked out one of these rivets and it is before me as I write.

On examination of other rivets that could be seen in the rip, they were all the same, and it was strongly evident that the rivets had been forced into holes that were far from coming in line, necessitating the use of the drift pin, and practically shearing the rivet 15 to 20 per cent, as can be seen in the cut.

The question arises, how much were these out of line before the drift pin was used, and were they drifted as far as the makers dared to because of the usual liability attending this bad practice. It is evident that they lacked ⅛ in. in some cases of coming in line, and the rivet at white heat was put in and compelled to fit any misalignment of plate, even if it sheared the rivet half in two. With such workmanship, a tensile strength of 60,000 lb. for the plate or shearing strength of 38,000 lb. for the rivets is of no use, and the modern rule for figuring such boilers with such workmanship, ought to use 50 as a factor of safety instead of 5, 5½, 5¾ and 6, which is for good workmanship. Whether the Brockton boiler had this defect I am not prepared to say, except that either one, if figured by the modern rule and modern factor of safety of 5.5, was carrying more pressure than was safe, not to say anything of the defective riveting.

The U. S. government appoints inspectors to attend the preparation of all meat products in the slaughter

houses and stock yards all over the country, and their place of business is the slaughter house. How much less is it necessary to have boiler inspectors, whose place of business is the boilermaker's yard, and who shall superintend and have power to compel first class workmanship, and prohibit the use of the drift pin?

Lynn, Mass. A. C. Waldron.

Shearing Strength of Rivets

Editor Practical Engineer:

In answering J. H. P. on page 36 of the March issue, it was stated that the shearing strength of each rivet is 38,000 per single shear and 70,000 per double shear. These figures are for the square inch and not per rivet, which has an area of only 0.5185 sq. in. Therefore, the shearing strength of four rivets in double shear and one rivet in single shear would be as follows:

Strength of 1 rivet in single shear is 0.5185x38,000=..... 19,703 lb.
Four rivets in double shear is 0.5185x4x70,000= .....145,180 lb.

Total shearing resistance.....164,883 lb.

Los Angeles, Cal. F. G. Cobb.

Location of Trap in Vacuum Heating System

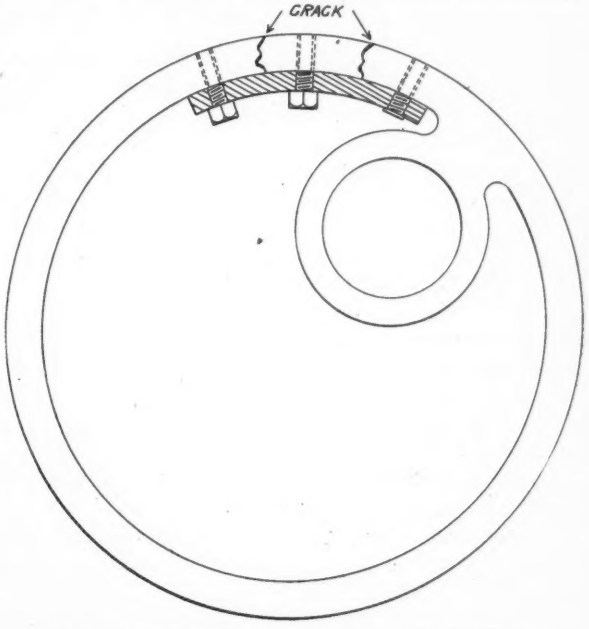
Editor Practical Engineer:

There is a question I would like to bring up for discussion, and that is in regard to vacuum heating systems in which exhaust steam is used. Is it good practice to place a trap, say an ordinary float or bucket trap, between the pump and the coils of the heating system? Is it not better to reduce the outlet leading to the pump, as with the trap the vacuum could only be formed between the trap and the vacuum pump? Is it not considered necessary to have the vacuum pump work on the coils in order to remove the air and condensation in order that the steam may have no impediment in its passage through the coils? I have seen this tried both ways, and the system with the trap placed at the outlet always failed to give the required amount of heat unless the back pressure valve of the engine was weighted down to force the steam through the coils, whereas the system without the trap had from 20 to 30 deg. more heat than the other. It has been claimed that without the trap the steam would enter the pump and destroy the vacuum. I have operated quite a large system of vacuum heating, using exhaust or very low pressure steam, and have never had this trouble exist. I think it would be a matter worthy of discussion in these columns, as the question of vacuum pumps for heating systems is generally acknowledged to be a vast improvement over the old systems. The writer has used vacuum pumps in connection with the cylinder dryers of a paper machine with the best of results. All engineers who have had charge of the steam end of a paper mill will readily admit that the economical operation of these dryers was one of the hardest propositions they had to encounter. H. I. M.

Repairing a Broken Eccentric

Editor Practical Engineer:

The eccentric on the belt-driven pump broke in two places for me recently, and as it was the only pump I had to feed the boiler with, and as it would take me a week or more to get one from the factory, I patched up the eccentric with 6 studbolts and a plate, as shown in sketch, and it worked o. k. I could not place nuts on two of the studs, so I reamed the holes larger



REPAIRING ECCENTRIC WITH PLATE AND STUDBOLTS

on the ends and upset the bolts. After all the studs were screwed in I filed them off so that they would not cut in the bearing.

South Bethlehem, Pa. G. O. B.

What Caused Collinwood Disaster

Editor Practical Engineer:

I would like the opinion of the readers of the Practical Engineer in regard to the coroner's report on the Collinwood fire, stating that the steam pipes set fire to the building.

I was on the ground, and received the following statement from the janitor: There were two steam furnaces, each holding about 100 gal. of water, with the safety valve set to blow off at 10 lb. In very cold weather they carried from 5 to 7 lb. of steam, and at the time of the fire there was less than 2 lb. of steam. All of the radiators had just been closed. The pipe in question was the return pipe to the furnace. The fire started about 20 ft. from the furnace, and when it was first discovered in the basement under the front

door, it was very small. The janitor then sounded the gong on the first floor and the children rushed for the rear door. By the time they reached the door the fire was there, a distance of about 60 ft., and in 2½ min. the building was in one solid mass of flames. Everything was all over in 10 to 12 min. There was no gas in the building, as it was lighted by electricity. It was a modern brick building, and the live steam pipes were covered with asbestos.

Please give your opinion as to what caused the fire, if not the pipe in question. B. B.

Cleveland, O.

Making Cover for Dashpot

Editor Practical Engineer:

The accompanying drawings will show how I made a cover out of heavy tin for my dashpots, so as to keep the dust and dirt from getting in too freely. This cover is to be made large enough to fit nicely over the top of the dashpot and the hole in the cover must be made large enough so as to slip over the rod and to leave room enough around the rod so the air can pass out when the dash is on the upward stroke without lifting the cover.

A rim can be put on the cover by turning up a flange on the rim after it is soldered, and of the right diameter. Then by turning the edges of the top down, fitting the rim in place and turning the edges of the top under and up tight against the flange, the job is finished.

An explanation of the rule used in making the dashpot covers is as follows:

First, draw line A, as shown in the diagram, then draw line B, equal to one-half of the diameter of the cover, and at right angles to line A. Lay off the length or height desired from line B on line A, and draw line C at right angles to line A, equal to one-

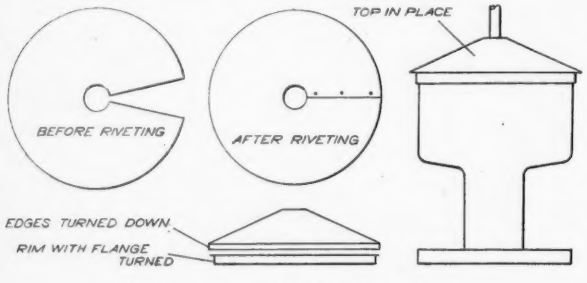


FIG. 1. DETAIL OF DASHPOT COVER

half the diameter of the top. Then draw line D from line B to line C, up to line A, cutting it at O. Set the dividers equal to line D from O to B, place the stationary leg at O, and draw as much of circle E as you think necessary. Then set the dividers equal to the distance between lines D and A on circle E, and space off six times this on circle E, as shown. At the point 6 draw line F to point O. Now set the dividers equal to the distance between line C and point O on line D and draw circle G to line F. If lap is desired to fasten the ends together, add this on by drawing line H parallel to line D, at a distance equal to the required lap. Then by cutting along lines F, E, H, D and G, the job is finished and ready to be put together.

Fertile, Minn. Chas. H. Sparber.

Correcting Wattmeter Readings

Editor Practical Engineer:

A better technical method of calibrating polyphase wattmeters for switchboard service than that advised by Mr. Harrar in his article, "The Measurement of Power on Three-Phase Circuits," is the following:

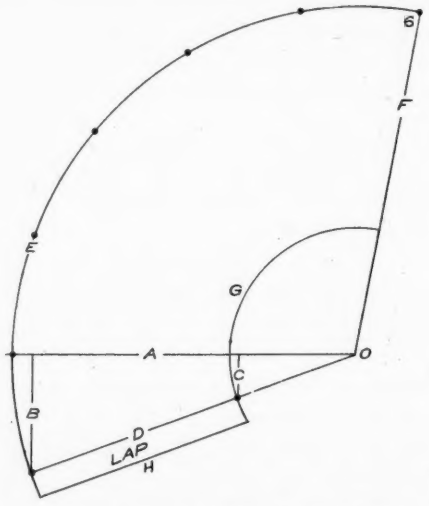


FIG. 2. METHOD OF LAYING OUT AND CUTTING COVER

Arrange a single-phase wiring of the desired frequency. Connect the meter and let the shunt coils be connected to a potential of 100 v. or slightly more and the series coils to a current of 5 amp., which can be obtained by using a suitable number of incandescent lamps. The full scale value of the meter, no matter what it may be, is equal to 500 watts (100 volts x 5 amperes). Since these two ratios are fixed values for any capacity, adjust the movable part of the meter (and not the pointer, as Mr. Harrar said in his article; the pointer should never be touched in any case) in such a way that when you read 500 watts on the controlling instrument, the pointer rightly stands on the extreme mark of the scale. To be more precise, apply half of the calibrating power, 250 v., and see that the pointer stops at half scale.

The meter is now calibrated and perfectly balanced, and is ready to measure the true power on any circuit of two or three-phase, balanced or unbalanced. All this applies in the case that the meter was already compensated for the running friction and power factor.

To calibrate the meter at half-scale does not mean that it will measure the full deflection, on account of the balancing which may not be exactly the same

in all parts of the rotation; at least this applies in particular for meters of the induction type, where a rotor in the form of a drum is mounted on a light shaft, the bearings being jeweled.

Newark, N. J. C. P.

Why Generator Did Not Compound

Editor Practical Engineer:

In the June, 1907, issue of the Practical Engineer, page 28,"Why Does not the Generator Compound?" Will say for the benefit of those who tried to help me out, that the trouble was found. The main circuit breaker also closes the equalizer contacts. The main current passes through the breaker in a perpendicular plane and the equalizing current passes through the breaker in a horizontal plane. A poor equalizing contact was the trouble, caused by a new handle on the main breaker, that was not quite the right size and shape.

I would like to see F. S. H.'s, of Mt. Tom, Mass., answer to his third question of January, 1907, issue, page 26. C. E. N.

Solid End Plungers in Deane Pumps.

Editor Practical Engineer:

In the letter on "The Effect of Hollow-End Plungers," by G. G. McV., April issue, page 30, there appeared the following statement: "In answer to J. C. H. as to hollow-end plungers, I suppose from its action, as stated by him, that the pump is the Deane Vertical. Otherwise, the hollow plunger will in no way interfere with the working of the pump."

In reading this article, an erroneous impression might easily be conveyed, as it would seem to indicate that the Deane Vertical pumps were built with an open end plunger. On the contrary these pumps, whether of the steam type or power type, are built with solid ends in the bottom of the plungers, in order to prevent the loss in capacity which would occur, owing to compression of air, if the plungers were built with open ends. The action of an open end plunger would be as described in the letter and would seriously affect the operation of a vertical pump. The Deane, of Holyoke, pumps do not have the objection stated, so that the statement cannot very well apply to this make of pump. C. L. N.

Curing a Bad Pound

Editor Practical Engineer:

Some time ago an engineer, running a plant in a suburban town, asked me to see if I could help him with his engine, which was making an awful racket. The engine was a 12x24-in., of the double piston valve type, running 125 r. p. m.

The engineer said he had not disturbed the setting of the valves, but one morning he started the engine with the cylinder cocks closed, and the result was a broken rocker arm shaft. He was sure this had nothing to do with the pounding of the engine, as he had a new shaft made exactly like the old one, but the machinist in cutting the keyway didn't take in considera-

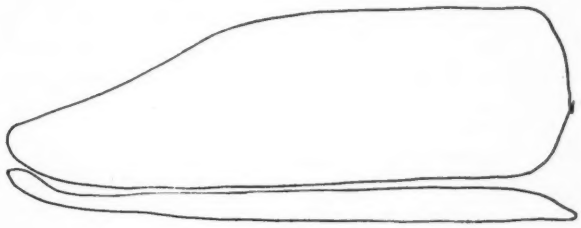


FIG. 1. CARD TAKEN BEFORE ADJUSTMENT

tion that the shaft was twisted off, so he did not get the keyway in the right place on the new shaft.

After adjusting the indicator, I got card No. 1,

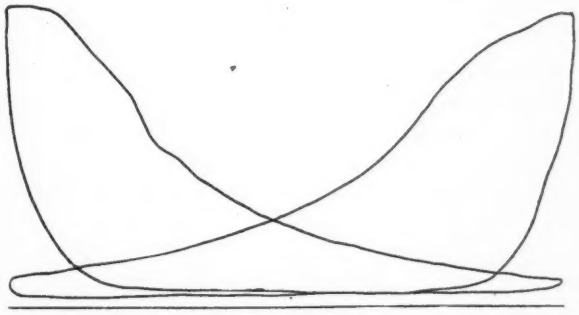


FIG. 2. AFTER ADJUSTING VALVES

and finally No. 2. The old engine is now running quiet as a sewing machine. F. E.

Chicago, Ill.

Rule for Finding Size of Boiler for a Given Engine

Editor Practical Engineer:

As none of the books that I have contain a good practical rule for finding the boiler capacity for any size engine, the following rule may be of help to someone:

"Multiply the horsepower of the engine by the number of pounds of steam the engine will consume per indicated horsepower per hour, and call this product I. From the number of heat units contained in 1 lb. of the steam above zero, subtract the number of heat units in 1 lb. of feed water and multiply this result by product I and divide by 34½ (the number of pounds of water evaporated from and at 212 deg. to develop 1 h. p.). The result will be the required commercial rating of boiler."

Fall River, Mass. W. S.

AN 18-FOOT "hydro-curve" boat recently attained a speed of 45 miles an hour on an Illinois river.

WHY THE D VALVE CANNOT CUT OFF EARLY

WHAT is known as the simple D valve takes its name from its resemblance to a capital D, turned with the flat side down and having that side practically all removed. The arrangement is, as shown in Fig. 1, with the ends of the valve the same width

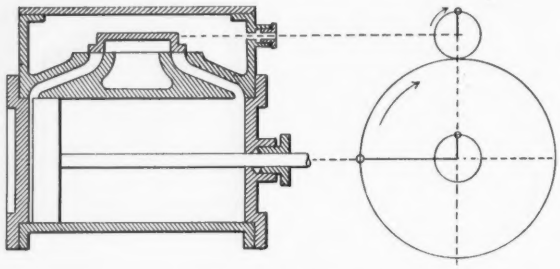


FIG. 1. POSITION OF D VALVE WITH PISTON AT HEAD END OF STROKE

as the ports, so that the valve just covers the ports when it stands directly over them or in "mid-position." The valve is usually driven by an eccentric, which is a crank in which the crank pin has been allowed to grow until it has swallowed up the shaft,

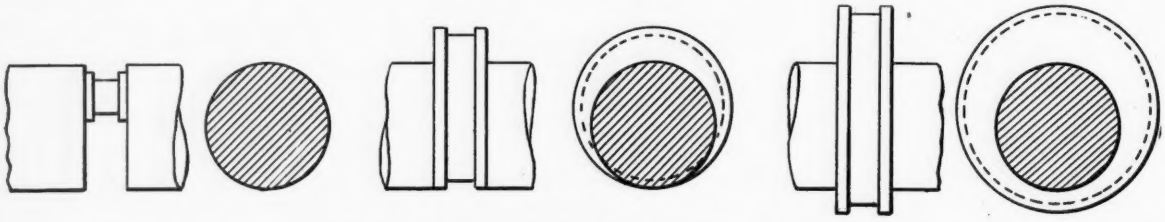


FIG. 2. THE RELATION OF THE ECCENTRIC TO A CRANK PIN

as will be seen from a study of Fig. 2, the idea of which is borrowed from Professor John Perry. With this mechanism, the center of the eccentric must be at the 90 degree point on the eccentric circle in order that the valve may be in central position. The piston is at the beginning of a stroke, all as shown in Fig. 1.

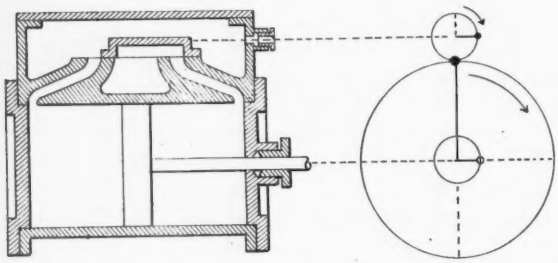


FIG. 3. MID PISTON POSITION; VALVE AT EXTREME RIGHT

Suppose that the direction of running is as shown by the arrow; as soon as the shaft starts turning, the valve will be drawn to the right and the port at the left-hand or head end of the cylinder will be opened to steam, and that at the right-hand or crank end of the cylinder to exhaust. This will force the piston to the right. The further that the shaft turns, the more will the valve be moved to the right, until the eccentric center reaches its extreme position at the right of the eccentric circle; then the valve will commence to move to the left, this extreme position being shown in Fig. 3. The force of the steam will continue to push the piston to the right, however, until the valve again reaches mid-position and the eccentric tric is directly at the bottom of the eccentric circle, at which time the piston will have reached its right-hand dead point as seen in Fig. 4.

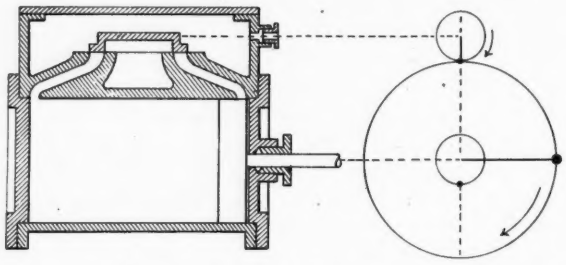


FIG. 4. MID VALVE POSITION; PISTON AT CRANK END OF STROKE

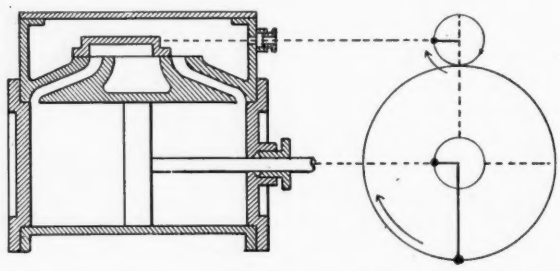


FIG. 5. MID PISTON POSITION; VALVE AT EXTREME LEFT

Continuing the motion, the eccentric will move the valve to the left, which will open the right-hand end of the cylinder to steam and the left-hand end to

exhaust, thus forcing the piston to the left, the valve coming wider open until the eccentric reaches its left-hand position as seen in Fig. 5. After that, the valve moves to close until the mid-position of the valve is reached and the piston is at the extreme left, as in Fig. 1, and conditions are as at the beginning.

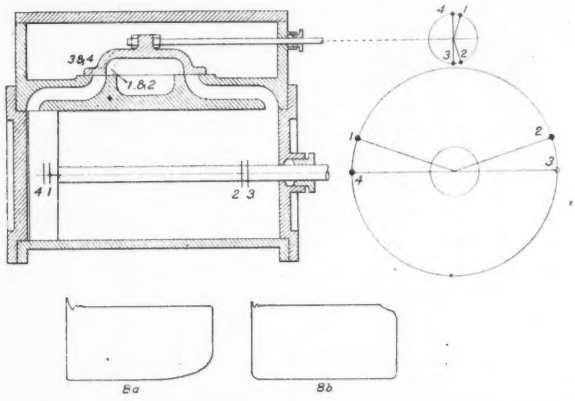


FIG. 6. D VALVE ADMISSION AND CUT OFF WITH LAP ADDED
FIG. 8. DIAGRAMS FROM CYLINDER WITH PLAIN D VALVE AND WITH D VALVE HAVING LAP

This device will work, but it allows the steam to enter throughout the whole stroke so that there is no chance for it to expand. The engine will work the steam at full pressure, which is too wasteful for any but the smallest and crudest of machinery, hence, something better has to be found. If the valve has a projection which extends beyond the edge of the port on the outside end, this will close the port before the piston reaches the end of the stroke so that the steam will have a chance to work expansively; this addition also delays the admission of steam at the beginning of the stroke, however, a condition which is bad, and the eccentric must be turned ahead on the shaft until the admission is brought at the beginning of the stroke. But this turning ahead will further advance the cutoff of the steam. The time of opening and closing the port with the lengthened valve are shown in Fig. 6, and the times after the eccentric has been set ahead in Fig 7.

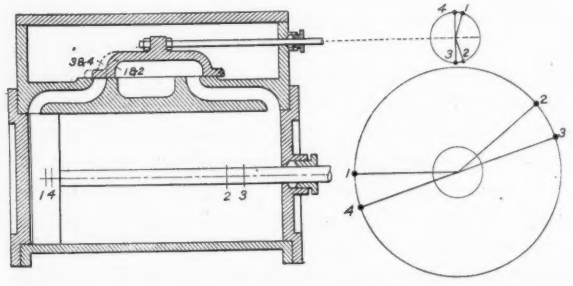


FIG. 7. D VALVE ACTION WITH ECCENTRIC ADVANCED TO CORRECT FOR LATE ADMISSION DUE TO LAP

This effect is very satisfactory so far as the steam end of the valve is concerned, but what about the exhaust end? Here the opening and closing will both be earlier and the steam will be let out of the cylinder before the piston has reached the end of the stroke, while the early closing results in the compression of the steam caught in the cylinder, with rise of pressure. The probable indicator diagrams from the two cases: no cutoff and no compression, and cutoff and compression are as shown in Fig. 8.

The more that is added to the valve on the steam end, the earlier will the cutoff come. Also the eccentric will have to be turned farther ahead to bring the admission right, and this again will make the cutoff yet earlier; but also, as the cutoff is thus made earlier, the release of the steam is brought earlier,

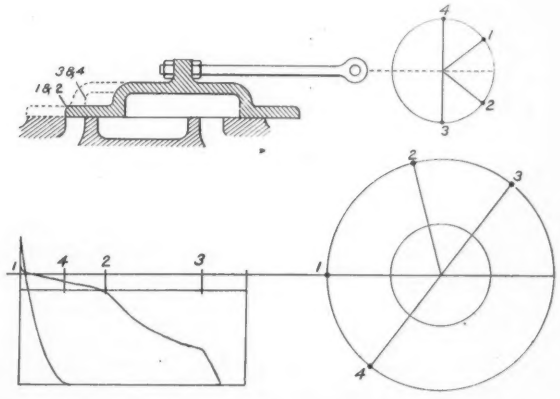


FIG. 9. ACTION OF D VALVE DESIGNED TO CUT OFF AT 3/8 STROKE
FIG. 10. DIAGRAM WITH VALVE ACTION AS IN FIG. 9

and the closing of the exhaust earlier so that the compression is greater. These last two effects will soon become too extreme to be satisfactory.

When the valve has had something added to it on the end, it will extend beyond or "lap" over the edge of the port as it stands in middle position; and the length that it sticks over is called the "lap" of the valve. Also the angle through which the eccentric is turned ahead to bring the admission right after lap is added is called the lap angle, and is measured ahead of the position the eccentric has when there is no lap, which is 90 deg. ahead of the crank. We may then say that with large lap there must be large lap angle and there will be early cutoff.

In order to see how the large lap works out, examine the action when there is lap enough to bring the cutoff to 3/8 stroke. The method of finding how much lap is needed will be considered in a later article, but for now, take it as found by trial. With so large a lap as is required, the angle of lap is large, Fig. 9, and the eccentric has but a little way to move after the valve opens before the extreme position of motion is reached and the valve begins to close. This results in too small a valve opening, so that the steam

is wiredrawn and the initial pressure greatly reduced before cutoff occurs. Examining the action of the exhaust end of the valve, it is found that the release of the steam comes long before the end of the stroke, and the exhaust closure so early as to make the pressure due to the compression of the steam altogether too high for good results. The indicator diagram as produced under these conditions is as shown in Fig. 10. This is evidently not an allowable set of conditions, and the need for early cutoff must be compromised with the need for better action on the exhaust end of the valve. Trial and experience show that the practical limit for cutoff with the D valve is about ⅝ stroke, although a passable action may be had with careful design with cutoff at nearly ½ stroke. There is likely, however, to be a considerable loss in the pressure of the steam, due to the wiredrawing previously mentioned.

HOW GAS ENGINES OPERATE

HOW the gas engine operates or what is going on within the cylinder is a question which often puzzles the beginner and a great many of the old-timers who have only had experience in a steam plant. There are a great many different makes of gas engines, some vertical, some horizontal, and each differing in their mechanical construction, but with a very few exceptions they may be all grouped under two distinct types, and are known as four-stroke cycle engines or two-stroke cycle engines. These terms are often abbreviated and the engines are usually spoken of as four-cycle or two-cycle, depending on which type they belong to.

How these strokes occur in the four-cycle engine will be understood by reference to Fig. 1, which is a set of four diagrams showing the direction of motion of the piston in the four strokes of the cycle. For the sake of simplicity, the drawings are made in dia-

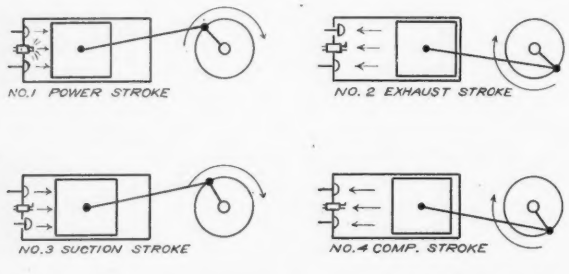


FIG. 1. DIAGRAMS ILLUSTRATING THE FOUR-STROKE CYCLE

gram form but may be readily applied to an actual engine. The first diagram is an illustration of the power stroke. Here both suction and exhaust valves are closed and the igniter has just sparked, exploding the gas and driving the piston in the direction indicated by the arrows. When the piston reaches the limit of its travel in this direction, the exhaust valve opens, and as there is still a little pressure within the cylinder, the greater part of the burn. gases instantly escape. Whatever gas remains in the cylinder is forced out on the return stroke of the piston. This is known as the exhaust or second stroke of the cycle.

The piston is now at the left hand end of the cylinder, and is ready to move towards the crank on the third or induction stroke of the cycle. During this stroke a new charge of gas and air is drawn into the

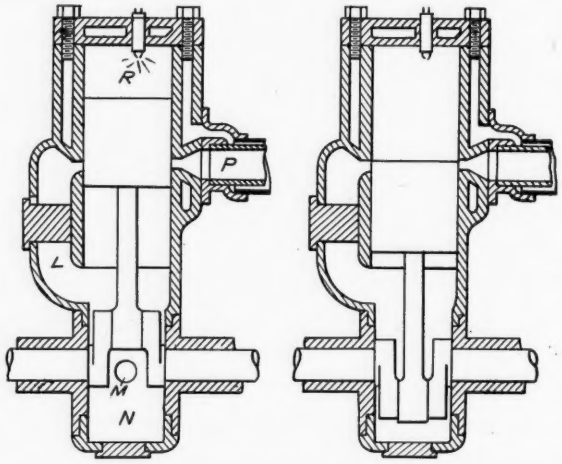


FIG. 2. ARRANGEMENT OF THE TWO-CYCLE ENGINE

cylinder, and when the piston returns to the left end of the cylinder on the fourth stroke, these gases are compressed into a small space. Naturally, this is called the compression stroke, and completes the cycle. The engine is now ready to start on a new cycle and repeat the four strokes in the same order as before. This it does indefinitely as long as it is running.

It will be noted that there is only 1 power stroke in every 4, or, as it takes 2 strokes to make 1 revolution, only 1 power stroke occurs in 2 revolutions. On this account the speed of a four-cycle gas engine is inclined to be very irregular, but in actual operation this variation in speed is overcome to a great extent, by using heavy flywheels and by duplicating the cylinders, using 2, 3 and even 4 for 1 engine. The cylinders are all connected to a single crank shaft, as is often done in marine steam engines. If 3 cylinders are used, the cranks are set 180 deg. apart, and from the 3 cylinders a power stroke is obtained every two-thirds of a revolution. With this arrangement the speed is almost as uniform as in a steam engine.

In the two-cycle engine an impulse is obtained every other stroke, and the cycle completed in one revolution of the crank. Thus, a working stroke occurs twice as often as in the four-cycle, and with the same size of cylinder nearly twice as much power is obtained from the two-cycle engine. Nevertheless, due to some defects in the design of this engine, the four-cycle is almost universally used in power plant work.

Figure 2 will serve to illustrate the operation of the two-cycle engine. In all the small engines of this

type the crank end of the cylinder is enclosed, forming a compartment to receive the charge of gas and air. As indicated in the illustration, the charge is drawn into the opening M, and as the piston descends, the gases are compressed in the crank case and forced up into the bypass L around the piston. As soon as the piston moves down below the opening from this bypass, the gases are forced into the cylinder and push out the burnt gases of the previous charge through the exhaust opening P on the opposite side of the cylinder.

When the piston starts on the upward stroke it soon closes both of these openings and compresses the fresh charge which has just entered the cylinder. As soon as the piston reaches the top point of its stroke the gases are ignited and force the piston down on the working stroke. It will be noted that the exhaust opening is a little higher than the inlet on the opposite side, so that the exhaust gases have a moment to escape before the fresh charge is admitted to the cylinder. This is shown in the diagram at the right of Fig. 2.

In short, the various operations may be summed up as follows: On its upward stroke the piston draws in a supply of air and gas into the crank case and compresses the previous charge in the space R. The compressed charge in the top of the cylinder is then ignited, driving the piston downward on the power stroke. This action compresses the new charge in the crank case to about 10 lb. pressure, so that it will readily flow into the cylinder as soon as the inlet is uncovered by the piston. When the piston has reached the lowest point of the stroke and uncovered the inlet and exhaust openings, it is ready to start over and do the same thing. It is thus plain that the cycle is completed in two strokes or in one complete revolution of the crank.

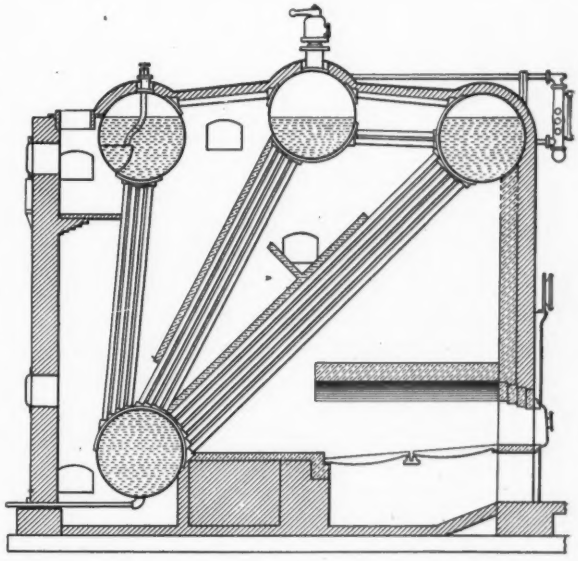
THE IMPROVED STIRLING BOILER, ERWOOD'S PATENT

RECENT rapid strides in the development of a fluid steel, have enabled John Erwood, a mechanical engineer and inventor, of Chicago, to introduce many needful changes in certain water-tube boilers, among them being the reconstruction of the Stirling boiler, a general reconstructed elevation of which is herewith presented.

The general outline of the old form of this boiler, wherein the banks of generating and circulating tubes are bent to individual contours in order that they may enter the faces of the drum sheets at right angles to their centers, so that they can be properly expanded into the tube holes, is undoubtedly familiar to all engineers.

In the form shown, representing a 15-tube boiler, something like 18 different shapes would be required to complete a single cycle or radial group, some of which cannot be drained of water and none which can be inspected by the line of sight throughout their length, and while it is possible to remove most of the scale by means of turbine cleaners when the boiler is closely watched for incrustation, it is a fact that cleaners operated by a pressure and hose connections, do not operate on all surfaces of a bent tube alike; the tendency to wear the heaviest on the outer circumference of a bent tube is apparent, and with a hose under pressure, is further aggravated by the tendency of a pressure hose to staighten, and not take kindly to a curve or corner. To overcome this objection is one of the objects of the Erwood patent.

This invention covers several forms of tube sheets,



STIRLING BOILER EQUIPPED WITH ERWOOD REINFORCED STEEL TUBE SHEETS

one of which, only, is here illustrated. It will be observed that straight standard stock tubes are employed, the entire interior being observable from the inside of any drum. The tube sheets are composed of cast steel of the required physical qualities, and the tube holes drilled out from the blank form in the usual way and by the ordinary means.

In some instances, where the tubes have been replaced, it has been found that the hole has been so enlarged by the previous expanding as to prevent another tube being replaced without the use of shims or gasgets. In the Erwood patent this defect is removed.

In the ordinary construction of this type, the longitudinal spacing of the tubes is usually alternate, every other space of such a width between the tubes as to leave sufficient room for the removal of a defective tube from the inside of the group, by passage between them of the defective tube.

It is believed that the new Stirling will be very popular, and that it can be built in small sizes and introduced in many branches where it has not so far reached. Further information can be secured if desired, from the inventor, John Erwood, 1604 W. Adams St., Chicago, Ill.

QUESTIONS AND ANSWERS

Our readers are invited to send in their troubles and problems; also to answer questions which are asked. All letters must have name and address of writer, which will not, however, be published. If answers are wanted by mail, send stamp for reply.

QUESTIONS FOR READERS

J. W. S.—How is the horsepower of a hoisting engine determined? For instance, if I have a truss of say 12 tons to raise with a gin pole and a set of blocks, double and single; 12 in. with the double block on top and single block on bottom, and rope running from double block on top to drum of engine. How many horsepower would be required to raise same?

J. C.—Please explain why the load increases on a link motion with open rods and decreases with crossed rods, as the link is moved either way; also the rule for setting the valves on a link motion.

QUESTIONS ANSWERED

Lowering of Power Factor in Alternating-Current Circuits

V. L. B.—In a recent discussion it was stated that the power factor of an alternating-current circuit was sometimes lowered by a distortion of the current wave, while the current and e. m. f. might still be in phase. I think most of us are familiar with the manner in which lagging and leading currents are produced, but the fact that a power factor is lowered by a distortion of the current wave, and current and

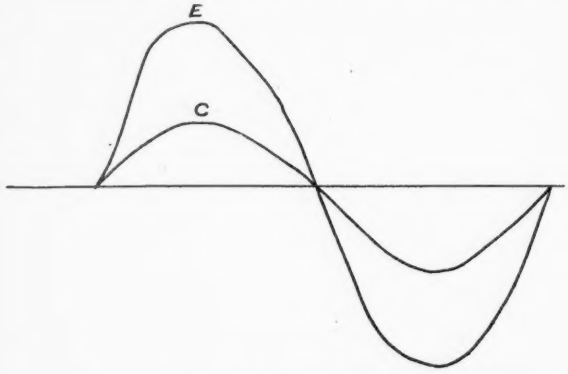


FIG. 1. CURRENT AND E. M. F. IN PHASE

e. m. f. still be in phase, was a new one to me. Can some one better versed in alternating current than I, explain how this condition is brought about?

A.—The way in which the power factor can be affected by distortion of the wave form may be indicated by the sketches herewith. In the ordinary form, which is approximately a sine curve, the peaks of the two curves, if the current and e. m. f. are in phase, will come opposite each other, as indicated in Fig. 1. Evidently, then, when we take the mean electromotive force and the mean current, the two will have their values in phase and can be multiplied together to get the mean power.

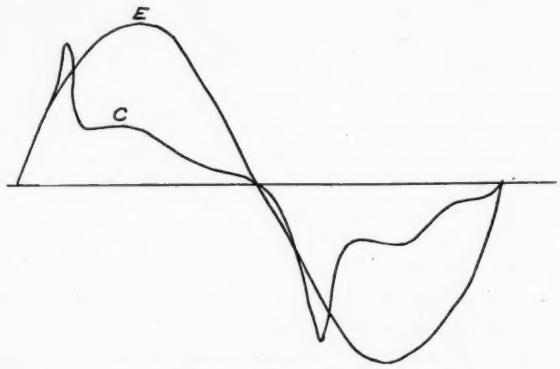


FIG. 2. CURRENT CURVE DISTORTED

If, now, the electromotive force curve remains a sine curve, while the current curve, due to the action of apparatus in the line or the construction of the generator, is distorted so that its peak is sharply out of phase with the maximum electromotive force, as indicated in Fig. 2, the effect will be that the main value of the electromotive force and the mean value of current do not come at the same time, and, therefore, multiplying these two values together will not give the mean power in the circuit. Too much importance should not be placed on this point, as usually where there is sufficient distortion of current to produce such an effect, it comes from inductive action in the line, which will affect the time relation of current as well as the form of the current wave.

Insulation for a Cooling Room

J. L. H.—I would like to obtain some information concerning a brewery racking cellar which is on the ground floor and piped for a temperature of 45 deg. The brew master, who had this matter in charge, claimed it was absolutely unnecessary for any lower temperature, and on the matter of insulation, he wanted none, claiming to get from some new York firm, a paint which was guaranteed to beat anything as insulation. The paint was nothing more than black asphaltum, but, nevertheless, the cellars were painted with this dope.

To begin with, the cellar has a volume of 14,189 cu.

ft., contains some 550 ft. of 2-in. pipe, and after freezing every foot of piping in there, we were doing extraordinarily well to hold the temperature at 48 to 50 deg. The ceiling to the cellar was the second floor, supported by open joists, and was made of 7/8-in. flooring, a layer of tar paper and some more 7/8-in. floor on top of the paper, then the joists and more flooring on top. On the end of the joists, for possibly 15 ft., are open, allowing the outside temperature to get between the top and bottom; also, the boards are beginning to warp badly. The building was built in 1846, consequently, the walls are rather dry and cracked. The side wall is only 12 in. thick, with whitewash on the outside and the asphaltum paint on the inside.

To insulate the cellar thoroughly would cost a large amount of money, so I suggested to use on the

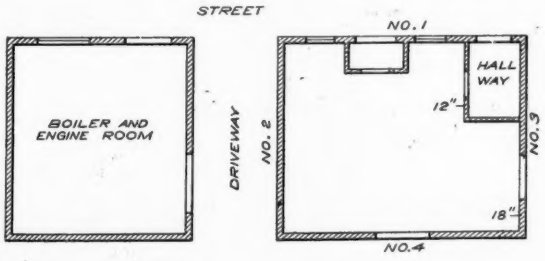


FIG. 1. PLAN OF POWER PLANT AND RACKING CELLAR

outside 12-in. wall good boarding, first cleaning and scraping same; then allow a good coat of pitch, and build probably 3 good partitions of wood. Pull up the top floor and fill in these open joists with a mineral wool or granulated cork, then put on a double floor with paper, etc., and also put in more piping, so that at least 38 to 40 deg. can be reached and maintained.

In Fig. 1, which is a plan of power plant, and first floor of brewery, wall No. 1 faces the street and is hot all day. Wall No. 2 is only 12 in., and receives considerable heat across the driveway from the boiler

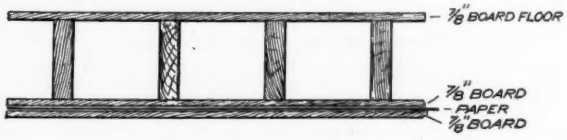


FIG. 2. CONSTRUCTION OF CEILING TO RACKING CELLAR

and engine rooms. Wall No. 3, where the stairs show, is 12 in. thick and 18 in. thick in the rear. The rear wall, No. 4, is 18 in. thick. Figure 3 shows an elevation of the racking cellar. Please let me know what you think of my suggestions for an ordinary, cheap job?

A.—In the main your recommendations are good. It seems unnecessary, however, to install more piping. First, fix the outer wall and the flooring above the racking cellar and this, undoubtedly, will give you as low a temperature as will be needed. The plan for taking care of the floor above the cellar is all right.

In stopping up the ends of the joists, put in bridging partitions between the joists at 6 in. from the end, as shown in Fig. 4, making these bridgings two thicknesses of 7/8-in. boarding, with a layer of building

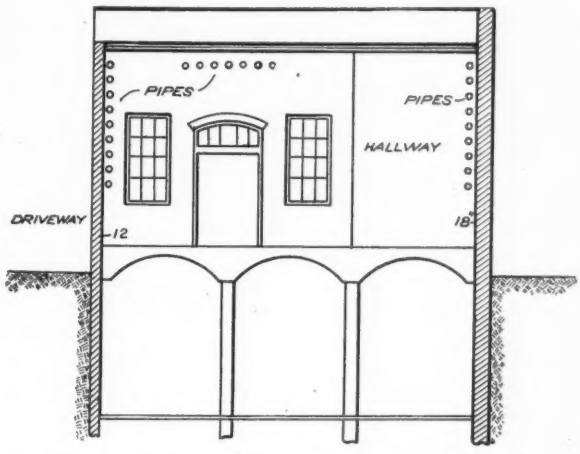


FIG. 3. ELEVATION THROUGH RACKING CELLAR

paper between. Then fill the spaces between the bridge and the end of the joists with cork or mineral wool, and put a stop partition across the end of the joists, made up of a layer of 7/8-in. boards, two layers of sheathing paper and a second layer of 7/8-in. boards. Cover the outside wall with pitch; then leave a 2-in. air space. Put up a partition of two layers of 7/8-in. boards, with two layers of sheathing paper between; leave another space of 2 in. and put up a second double

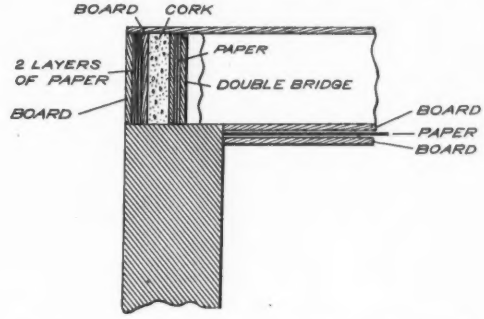


FIG. 4. METHOD OF CLOSING UP OPEN JOISTS

partition of 7/8-in. boards, with two layers of building paper between. This should give sufficient insulation, so that the present installation of piping will hold the temperature at or below 42 deg.

TO GET THE LENGTH of a belt where it is not convenient to measure, add the diameter of the two pulleys together, divide the result by 2 and multiply the quotient by 3¼. Add the product to twice the distance between the centers of the shaft and you have the length required substantially.

THE PIONEER OIL CUP

In our busy everyday life, we are rather apt to accept as a matter of course the present state of any art or line of industry. It is not possible for us to give time or attention to the development of that art or industry from its earliest beginning, concerned as we are with its daily improvement and betterment. Nevertheless, a little in the way of history is often quite interesting, having to do with present day development which is carried along on a great deal similar lines.

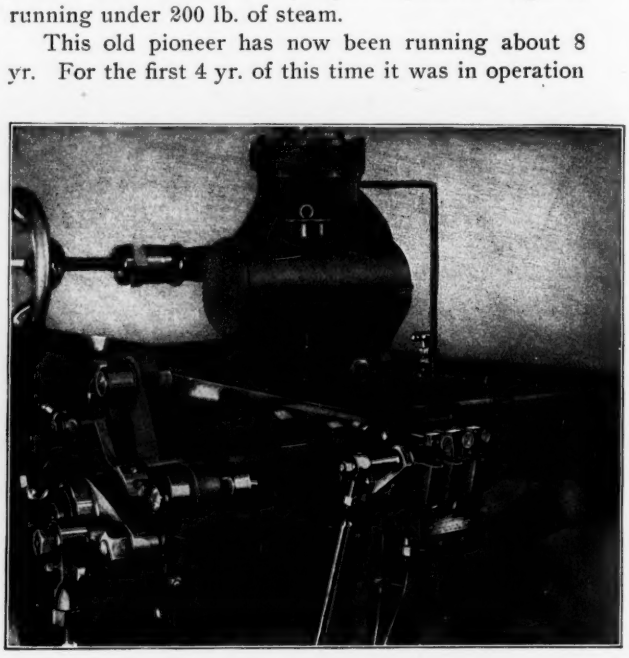
Some years ago, one of the erecting engineers of the Edw. P. Allis Company was in charge of a station, part of the equipment of which consisted of a very slow-moving pumping engine, working, however, with high-pressure steam. This pump was supplied with a common form of ratchet-driven oil pump, with the oil delivery lines piped into the steam chests. The little sight feed tell-tale device indicated, as the oil pump was operated, at certain times when the plunger of the little pump had been ratcheted around to the proper position, that a certain amount of oil was pumped through; just how much, of course, the arrangement did not show. With the slow-moving apparatus, the delivery of oil occurred at intervals of over a minute; and, when it did take place, of that quantity of oil which was forced suddenly into the steam, a large portion dodged on through the cylinder into the exhaust, and only a very small per cent did any good as a lubricant. For a few strokes after this oil delivery the engine would run quietly, and before the oil feed again took place it would begin to groan. Evidently, the most serious objection was the matter of frequency of oil delivery.

An ordinary lubricator was substituted for this oil pump, and the oil delivered to the steam line just above the throttle by means of a little quill which extended into the center of the pipe and was bent to spill downward at this point. The lubricator was set up close to the steam pipe in order to keep it warm, so that the drops would be as small as possible and therefore more frequent for a given quantity of oil per hour.

These experiments started a line of thought which revolved itself into a few rough sketches made on the return trip to the home office. These experiences and the deductions made in their light, as well as the sketches themselves, were shown to Edwin Reynolds who was at that time general superintendent of the Edw. P. Allis Company. Mr. Reynolds was quick to perceive the value of the idea, and requested that the device shown in the sketches be worked out and tried on an engine.

Backed by the encouragement of such eminent authority in steam engine matters, as well as by the sincerity of conviction, the manufacture of the first Richardson sight feed oil pump was commenced; the work being performed at odd times by Mr. Richardson and a friend. This pump, which is shown in the accompanying cut, was finally made and put on a cross compound Corliss engine, 20 and 30 by 48-in., which was used for supplying power to the shop. The performance was watched very closely and reports made by the engineer in charge. Its satisfactory behavior resulted in the placing of an order for some pumps to be used on the Corliss engines then being built. This was soon followed by an order for 16 to be placed in the Manhattan Station at New York, followed shortly by an order for 30 pumps for the New York Edison Company, which was secured as the result of a competitive economy test made at the Duane Street Station on triple expansion engines, running under 200 lb. of steam.

This old pioneer has now been running about 8 yr. For the first 4 yr. of this time it was in operation



PIONEER OIL PUMP ON CORLISS ENGINE

from 7:00 a. m., to 9:00 p. m., and for the past 4 yr. has been operating 5 days and 5 nights each week, having been under the care during all this time of one engineer, who reports that it has never been repaired, cleaned or molested in any way, and that the lubrication of the engine has at all times been entirely satisfactory.

The small oil tank shown mounted on the engine is occasionally removed and cleaned, but the pump takes care of whatever dirt may come its way through the oil or floating in at the open sight feeds.

A great many improvements have been made since the time of manufacturing this old pioneer, which have transformed the apparatus into a fully automatic machine, with efficient arrangements for compensating for wear; but the fundamental principles arrived at by observing the operation of the slowly moving pumping engine, and the design of apparatus worked out at that time to overcome the difficulties, still form the secret of success attained by the positive driven oil pumps of this style.

A PRACTICAL METALLIC PACKING

For some years, engineers have felt the necessity for a packing that should be especially suited to the high pressures and high piston speeds of modern engines. Fiber packings, because of their tendency under such conditions to blow out, or to carbonize and cut the rod, have proved so uneconomical and unsafe, that inventors have turned their efforts toward the manufacture of a packing that shall be entirely metallic, or at least mineral in its composition. A metallic packing which has met with unusual success is Ambest. This is composed of long pliable filaments of nonfriction metal, treated with a special mineral lubricating compound. To place it in a stuffing box one simply twists it into a rope of suitable thickness, and jams it into the box with a soft stick. In service, the parts next the rod wear to a smooth solidity, while away from the rod it retains its original fibrous conditions. It will withstand the highest pressures and speeds, and up to 600 deg. F. is not affected by temperature. As an ammonia packing it gives excellent service. It is made by the Canfield Mfg. Co., of Philadelphia.

LOOSE PULLEY LUBRICATION.

If there is any one place where positive, automatic and regular lubrication is absolutely essential to insure safety, efficiency and economy, such a place is the bearing of a loose pulley. Every engineer knows, from actual experience, the difficulties encountered in that direction.

The reason lies in the strong centrifugal force exerted, the tendency of which is to prevent the lubricant reaching the journal, except in a spasmodic, irregular fashion. If oil is used, the centrifugal force tends to keep it in the cup away from the journal all the time the pulley is in motion, so that practically the oil flows only when the pulley is idle and with the cup in a vertical or nearly vertical position. Of the oil then gravitating to the journal the larger part is thrown off and wasted as soon as the pulley is again in motion, smearing everything within reach and making a dirty mess generally, not to mention the danger from fire, damage to belts from oil soaking, etc. In other words, most of the oil reaches the journal when least needed, and very little gets there at the crucial moments, which is the very reverse of what good practice and safety demand.

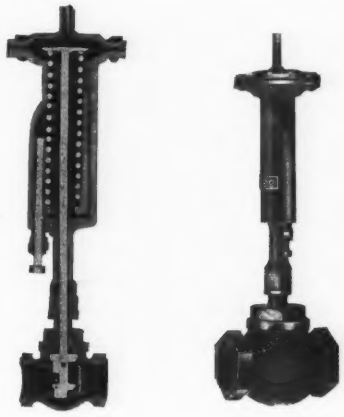
Grease, because of its controllability and great viscosity, is superior to oil for lubricating loose pulleys, and indeed for all machinery bearings. But, even with grease great difficulty has been experienced in its feeding because of the same centrifugal force. It is possible, however, to insure perfect lubrication by overcoming one natural force—centrifugal—with another natural force—compressed air;— and so the difficulties heretofore encountered in loose pulley lubrication are entirely removed by using any good cup grease in the Philadelphia grease cup.

In this cup nature supplies the feeding force in the form of compressed air, which fills the upper part of the cup. There being no weight in the motive power, centrifugal force cannot displace it, and the expansive power of the air exerted in the direction of least resistance insures an automatic, constant, even flow of grease to the journal. Furthermore, grease fed under air pressure reaches the journal unchanged in either its consistency or lubricating quality, performs its full work as a lubricant, and the net result is cool running pulleys with a remarkable degree of economy.

The Philadelphia grease cup has the unqualified approval of many engineers of high standing, and full information regarding it will be cheerfully supplied by the sole owners and manufacturers, the Philadelphia Lubricator and Mfg. Co., the Bourse, Philadelphia, Pa.

THE "S-C" PUMP GOVERNOR

A pump governor which has been designed for the purpose of giving a reliable and sensitive feed to boiler feed pumps, is shown in the accompanying illustration, The governor consists of a double diaphragm, one side of which has free connection with the water line to the boiler, and the other to the steam line to the pump. The steam side is elongated to hold a spring, an adjusting yoke and screw, and a plate on the valve rod. The plate is pressed toward the diaphragm by the spring which unbalances the governor, and opens the valve, admitting steam to the pump which feeds the boiler.



"S-C" PUMP GOVERNOR IN SECTION AND EXTERIOR VIEW

When the water in the boiler has attained the desired height, the feed line is closed or throttled, either by a water-level regulator, or by a hand wheel, and the pressure will rise in the feed line, overcoming the steam pressure combined with the spring, so that the flow of steam to the pump is retarded. As soon as the pressure in the feed line is relieved by admitting water to the boiler, the spring again pushes the diaphragm over and opens the valve in the steam line.

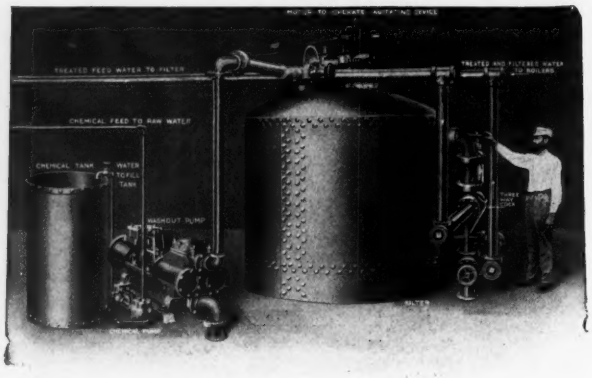
The governor is set with the diaphragm, downward; hence both sides of the chamber are filled with water. This water, having to pass back and forth through a small opening, serves as a cushion and prevents slamming and pounding of the pump.

The "S-C" pump governor is made entirely of brass, and can be located any place in the steam line. It is sensitive to work to ½ lb. back pressure, and requires no other attention than the reseating of the steam valve, just as any other steam valve requires. It is guaranteed to regulate and control any boiler feed pump under any pressure and under any condition where a pump can be made to work. The "S-C" Regulator Co., corner Perry and High Streets, Fostoria, Ohio, is the manufacturer.

FILTER INSTALLATION FOR SMALL PLANT

Managers of small power plants are often deterred from installing filtering apparatus, even when it is needed badly, because they think the expense greater than would be warranted by the saving effected. The Zahn and Bowley Co., of Rutherford, N. J., however, has installed, recently, for its 100 h. p. Parker boiler, a Keystone pressure filter system as shown in the cut; and figures prove the cost to be more than justified.

Before the installation, the boiler tubes were incrusted to a thickness of 5/8 in., with a scale composed



KEYSTONE PRESSURE FILTER SYSTEM

principally of carbonate of lime and magnesium. Experiments have shown that ½ in. of boiler scale necessitates the consumption of 60 per cent more fuel than is required when the tubes are clean; and it is also well known that the increased temperature required to penetrate scale softens and shortens the life of the boiler tubes. Taking into consideration only the waste of coal, however, it was found that at the smallest calculation a saving of $4 a day would be effected by keeping the tubes clean. Such a saving warrants easily an investment of $6000; and we need hardly say that this Keystone filter equipment, which has proved thoroughly efficient, did not cost anything approaching such a sum.

As may be seen from the cut, the apparatus is simple and compact, and no settling tanks are required. The treatment consists of precipitating the dissolved impurities as insoluble phosphates, and then filtering them out through a bed of especially prepared quartz. No other means has proved effective for water such as this, which, even when perfectly clear, and, apparently, perfectly pure, contains 9 grains of carbonates of calcium and megnesium per gallon. Mere filtering cannot affect these dissolved impurities; and it is not until they are precipitated through chemical treatment as solids that removal is possible.

Further information regarding this installation may be obtained by addressing the Keystone Chemical Mfg. Co., Philadelphia, Pa.

THE DAVIS BACK PRESSURE AND RELIEF VALVE

The Davis combination back pressure and relief valve, manufactured by G. M. Davis Regulator Co., Chicago, is an automatic valve designed to serve either as a noiseless back pressure valve for heating systems or as a relief valve in connection with condensing apparatus.

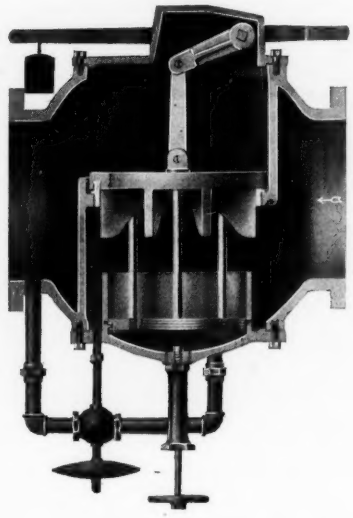
One of the several patented features and one that attributes largely to its success is the vacuum breaker, communicating with the chamber under the semi-balancing disk in the dash pot. It acts essentially to make and break a check valve seal. When a high vacuum is created in the condenser, it is also created in the chamber under the disk in the dash pot. Should conditions be suddenly changed to pressure conditions due to the failure of the condensing apparatus or due to the demand of the turbine, the main disk could not raise from its seat, as the vacuum still remaining in the chamber under the disk would hold the main disk tightly to its seat. In this emergency the vacuum breaker acts instantly and automatically and dissipates the vacuum conditions in this chamber by allowing atmosphere to enter, thereby balancing the two disks, and making the valve a noiseless semi-balanced back pressure valve.

Under these atmospheric conditions the valve relieves to the atmosphere all excess pressure above a predetermined point. In changing back to the vacuum conditions the vacuum breaker automatically seals all communication to the atmosphere.

Another patented feature of this valve is the construction of the main disk in relation to its seat. It prevents the chattering of the disk on its seat when a small volume of steam is passing out to the atmosphere. These several features enable many users of these valves to so arrange their plants that they may be operated condensing during the summer months and noncondensing in winter, using this valve either as an automatic relief valve for the condenser or as a noiseless back pressure valve for heating purposes.

The G. M. Davis Regulator Co. manufactures these valves in Chicago in connection with its steam special-

ties. As will be seen in the accompanying sectional view, the body of the valve and the internal divisions are made of cast iron. The seat is a steam metal ring, screwed into the main port, and is the full diameter of the inlet of the valve. The semibalanced disk or inside valve is cast iron, except the portion that seats on the ring, which is babbitt metal, and the connecting rods, which are steel. The top member of the disk



SECTION THROUGH DAVIS VALVE

is guided to its seat by guiding wings, and the lower member, which is packed by metal expansion rings, is held in line by a dash pot. The inner valve is connected by a link to a crank, which is fitted to a shaft leading outward through a steam metal stuffing box. On the outer end of the shaft is placed a lever, which carries the weight. To prevent the formation of a vacuum in the dash pot under the lower member of the disk, which would otherwise occur and prevent the valve from opening freely, the following arrangement is used: Connection between the dash pot and the atmospheric side of the valve is made through a 1½-in. pipe; a check valve is placed in this pipe, which is controlled by a diaphragm in direct connection with the inlet of the valve. When the valve is working condensing, the inlet is under a high vacuum, and the check valve is held closed by the action of the vacuum on the diaphragm, thus effectively sealing the valve. When noncondensing, the inlet is under pressure, which, acting on the diaphragm, holds the check valve open and admits atmospheric pressure under the dash pot.

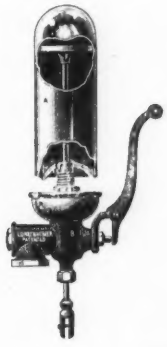
RESULTS OF TESTS of superheaters on the Canadian Pacific Railroad extending for a period of about 6 months show that a saving of from 10 to 15 per cent is realized in freight service and 15 to 20 per cent in passenger service over engines using saturated steam.

AN IMPROVED COMBINATION OR FIRE ALARM WHISTLE.

The cut herewith illustrates an improved form of whistle, manufactured by the Lunkenheimer Co., of Cincinnati, Ohio, and is known as a Combination or Fire Alarm whistle. It answers the purpose of an ordinary whistle, as well as a fire alarm, and is provided with a piston, to be worked up or down within the bell, thus changing the length, and consequently, also the tone. When the piston is not operated, the whistle gives but one tone, like any plain whistle, but when pulled up or down, a howling, penetrating noise is produced. An extension rod is connected to the fork of the bottom of the piston rod, when the whistle is placed above the roof of a building, and a rope or wire is attached to the valve lever, for the purpose of operating same.

At its upper end the bell is domeshaped, and its lower end is securely supported by a three-arm spider, the stem of which is adjustably screwed into the whistle base and fastened by a lock but. This construction keeps the lower edge of the bell always in line with the slot in the base, through which the steam escapes, thereby insuring best results by the production of a perfectly clear and loud tone.

There is quite a large number of this improved whistle used in small villages and the like, and



COMBINATION OR FIRE ALARM WHISTLE

wherever it is desired to produce a variable sound that can be heard from a considerable distance.

The Lunkenheimer Company also manufacture numerous other styles of whistles, among which are the "Plain Whistle," "Single Bell Chime." "Three-whistle Chime," and the "Mocking-Bird" whistle. They have recently issued an attractive booklet, printed in colors, illustrating and fully describing their various styles of whistles. which they will send upon request to those interested.

TO FIND THE HORSEPOWER a belt will transmit, multiply the diameter of the driver by the speed in revolutions a minute, divide by the desired speed of the driven. The quotient will be the diameter of the driven pulley.

PRACTICAL ENGINEER

HAS annexed all the editorial ability which has been directly responsible for the marked success of its late contemporary of similar name, with Arthur L. Rice, for 5 years editor in chief of that paper, as Managing Editor.

The time and energies of this staff will be devoted to keeping in touch with the needs of the power plant field and making PRACTICAL ENGINEER the best possible paper to meet those needs. The entire corps of writers, correspondents and specialists will contribute to PRACTICAL ENGINEER.

It is a paper for the Man Who Makes Things Go; to help him get them going, keep them running and keep down the cost.

PRACTICAL ENGINEER will bring you all the facts you need, as often as you need them, in shape so that you can get at them and use them. Its news will be REAL news FACTS. There will be sections or departments devoted to the latest Power Plants, Boiler Room Practise, Gas Engines and Producers, Electrical Machinery, Refrigerating Apparatus, New Developments in Science and Engineering, Hints from the Trouble Man. Letters from Engineers will give free discussion among readers of the every-day problems of the plant, and the Questions and Answers will bring help to the puzzled. A corner will be devoted to the hard points that bother the beginner in engineering.

All these things mean improvement—and a lot of hard work; but the editors are ready for the work, and only ask your kindly cooperation with their efforts for your welfare.

PRACTICAL ENGINEER

355 Dearborn Street CHICAGO

THE BEST POWER PLANT MONTHLY

WILL be only $1 a year in price, but will be Five Dollars in value. This issue gives but a hint of what it will be like when the plans for its betterment are worked out. Spite of this betterment, until July 1, 1908, two years' subscription will be given for $1, three years for $1.50, or four years for $2. There was never such a chance to get much for little. More REAL information than you can get anywhere else for five times the money. Four years' good reading, over 2800 pages, and a complete news bureau service on your specialty for $2. The offer isn't for long. Take advantage at once,

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NEWS NOTES

I HAVE MUCH PLEASURE in being able to notify the clients and other friends of The Westinghouse Machine Co. that the receivers appointed October 23, 1907, by the circuit court of the United States for the western district of Pennsylvania, were on March 31, 1908, discharged by the same authority. All of the matters which made a temporary receivership expedient have been satisfactorily arranged, and the company's position is greatly strengthened from every standpoint.

All contracts made by the receivers for the sale of the company's product, or for the purchase of materials or merchandise will be carried out as though made by the company's own officers.

I take this occasion to announce the election of William H. Donner as the vice-president of the company in direct responsible charge of all of its activities, and to give the assurance of the continuance and accentuation under Mr. Donner's administration of that steadfast policy whereby the clients of The Westinghouse Machine Co. have become friends as well as customers. G. Westinghouse, president.

LIBERTY MFG. CO., of Pittsburg, has purchased the separator business of Greenaway & Co., of Detroit, and in future will fill orders for steam, oil, ammonia or air separators manufactured under the Greenaway patents, in all sizes and types.

JAMES MCCREA & CO., Chicago, will remove its office and plant to 63 and 65 W. Washington St. The company's business of manufacturing pipe repairs and steam specialties, has grown to such an extent that this removal was necessary. The new location will give double office and manufacturing space.

THE EXECUTIVE OFFICES of the Westinghouse Electric & Mfg. Co., now at 111 Broadway, New York, N. Y., and the New York sales offices and export offices, of that company now at 11 Pine St., were removed on Monday, April 20, 1908, to the new City Investing Building, 165 Broadway, New York.

C. A. DUNHAM CO., Marshalltown, Iowa, recently made a large shipment of steam traps to a concern in Peru, South America. The traps shipped are for use in a heating system, and it was through the reputation of the Dunham trap for this class of work that the order was given. The shipment represents only one of several which the company is making to other concerns in foreign countries.

PERSONAL

RIVERSIDE ENGINE CO., Oil City, Pa., has removed its Pittsburg office from the Empire Building to the new Keenan Building. F. Louis Egan has been appointed sales agent for Indiana and Illinois, with headquarters at 1130 Congress Ave., Indianapolis. The Brown-Russell Co., of Fitchburg, Mass., have been appointed agents for the New England States. L. E. Safford, formerly Pittsburg sales manager for Clark Bros., Belmont, N. Y., and later general sales agent for the United States Engine Co., Parkersburg, W. Va., has joined the sales department.

E. H. WEBSTER, who has had several years' experience in the mechanical line and has a large acquaintance, has accepted a position with the American Steam Gauge & Valve Mfg. Co., and will make his headquarters at the Chicago office.

THE JACOBSON ENGINE CO., Chester, Pa., announces that it has appointed as representatives: F. D. McKercher, 1715 Prospect Ave., Cleveland, O.; Theo. R. N. Gerdes, 5 Van Nest Place, New York City; E. Kwartz, in Philadelphia, Pa. The Jacobson Engine Co. manufactures horizontal heavy duty gas engines for the automatic type for producer gas, ranging in horsepower from 20 to 500. Mr. Craven, of this company, reports business as being active, and that it has been necessary to run 24 hr. a day. Among some of the late shipments, were two large producer engines for the Pacific Coast and one large gas engine to operate on gasoline for Salt Lake City.

SOCIETIES

ON TUESDAY EVENING, April 14, a meeting was held in the auditorium of the Engineering Society's building, under the auspices of The American Society of Mechanical Engineers, in response to the invitation of President Roosevelt to engineers to co-operate for securing the conservation of our natural resources. A letter was read from the President expressing gratification at the zeal with which engineers had taken up this problem.

The meeting was presided over by J. W. Lieb, Jr., vice-president of the society, who introduced Dr. W. J. McGee, chief of the Bureau of Soils, Washington, D. C. Dr. McGee delivered an address on the Conservation of the Water and Woods, urging that it is time for a great revolution in which there shall be an awakening of a moral sense of obligation for the preservation of natural resources. One of the losses confronting the people of the United States is the loss of ground water. Too much flows away in torrents, because of the destruction of the forests. Instead of acting like a sponge, the earth, when stripped of its timber, sheds water like the roof of a building. The fertile soil washed away in the United States represents an annual loss of over $1,000,000,000.

Dr. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, speaking upon the Conservation of the Nation's Fuel Supply, said that economy in its production and use is to be enforced by a four-fold process. The necessary steps are, scientific research for the establishment of facts; practical demonstration of facts thus developed on a scale which will convince men that there is profit, direct or indirect, in a better practice; restrictive legislation which will protect the public from the competition of unscrupulous men; and finally, effective inspection which will secure an enforcement of law. The process cannot successfully begin with coersion; it must begin with education.

Prof. George F. Swain, of the Massachusetts Institute of Technology, Boston, presented the subject of Stream Flow, Water Power and Navigation. The most effective way of regulating stream flow is by preservation of the forests, and this produces three effects of great importance. It conserves one of our greatest natural resources—water power; it prevents erosion of the soil; and it prevents the filling up of navigable rivers and harbors as well as of reservoirs.

The concluding address, by Dr. Henry S. Pritchett, president of the Carnegie Foundation, treated of the attitude of the engineer towards the public. Engineering has grown into a profession that must consider public interests. The practical demonstration of professional ideals lies in the use of fair judgment, a sound sense of justice, and quick appreciation of the

larger public causes. The engineer not only plans, but carries out great enterprises. If he be a true member of his profession, he will, while loyally serving his employer, keep in mind the honor of his profession, the debt he owes to it and the service to the larger interests of humanity.

THE ANNUAL CONVENTION of the Ohio State N. A. S. E., is to be held in Springfield, Ohio, June 18, 19 and 20, 1908. As this has been the custom for a number of years, the manufacturers of engineer's supplies will again be given the opportunity for displaying their goods, and with this end in view, the committee has arranged for a commodious and well lighted convention hall, which is to be fitted up with booths; each booth to be enclosed and a counter on the front railing. Reservations are limited to not more than two spaces to any one concern, and assignments of space will be made in the order the applications are received. The committee has arranged with the Wagner Transfer Co. to handle all exhibits from the railroad station to the convention hall and return. All goods should be shipped and marked as follows: Care Wagner Transfer Co., Springfield, Ohio, number of booth in lower left hand corner. Freight to be prepaid and duplicate freight bill sent to the Wagner Transfer Co.

A PARTIAL LIST of the papers to be presented at the semiannual meeting of the American Society of Mechanical Engineers in Detroit, Mich., June 23 to 26, has been announced. It includes, A Method of Cleaning Gas Conduits, by W. D. Mount; A Method of Checking Conical Pistons for Stress, by Prof. George H. Shephard; Clutches, with Special Reference to Automobile Clutches, by H. Souther; Horsepower, Friction Losses, and Efficiencies of Gas and Oil Engines, by Prof. L. S. Marks; Some Pitot Tube Studies, by Prof. W. D. Gregory; The Thermal Properties of Superheated Steam, by Prof. R. C. H. Heck; A Journal Friction Measuring Machine, by Henry Hess; A By-product Coke Oven, by W. H. Blauvelt, and Tests of Some High Speed Steam Engines, by F. W. Dean. As has already been stated, there will also be a symposium on conveying machinery. The Society for the Promotion of Engineering Education and the Society of Automobile Engineers will hold their annual meetings in Detroit at this time.

BOOKS AND BOOKLETS

CONVERSATIONS ON ELECTRICITY, Part I, by Joseph G. Branch. Cloth bound, 254 pages, Chicago, 1908. Price, $2.

The book is an elementary work on the principles of electricity, written in question and answer form. No pretensions are made of showing the application of these principles to electrical machinery, as a second edition is to be devoted to this subject. The object of the book is to give a clear conception of electricity in static and dynamic form, primary batteries, magnetism, and the generation of direct and alternating currents, special attention being given the latter on account of its increasing use. In the way of illustration the book contains 96 zinc and halftone cuts, which aid materially in obtaining an understanding of the descriptive matter. As a question and answer compilation, the book is good, and comes as near fulfilling its purpose as might be expected of a book of this kind.

GARVIN MACHINE CO., New York City, in its Edition C of its catalog, describes standard milling machines of its manufacture. This catalog is international and is printed in German, French and English.

WAGNER ELECTRIC MFG. CO., of St. Louis, devotes a catalog recently issued to the use of the polyphase motor in the shop. It describes and illustrates the installation made in the shops of the Wabash Railroad Co. at Decatur, Ill.

THE OHIO BLOWER CO., Cleveland, Ohio, have just published an 80-page catalog of steam specialties which should be in the hands of every engineer. In simple language, with illustrations taken from everyday life, is explained the Helico-Centrifugal principle, which is applied in the design of the Swartwout cast-iron exhaust heads, steam and oil separators. Self-closing ventilators are also described, and helpful tables given. As a product of the printer's art this catalog could hardly be excelled. It is well worth sending for.

THE MASSACHUSETTS FAN CO., Watertown, Mass., has just issued an additional section of its perpetual catalog. This section, which comprises 16 pages, and is entitled Vertical and Horizontal Engines for Fan Driving, includes illustrations, descriptions, dimensions, and horsepower tables. The entire catalog is thus brought to a total of 116 pages of exceptionally valuable matter relating to blowers and exhausters, heating, ventilating, drying and mechanical draft apparatus, etc.

AMERICAN GASOLINE MOTOR CO., of Baldwinsville, N. Y., is issuing a catalog descriptive of castings and machine parts for the American marine motor, which is built in sizes from 1½ to 28 h. p., and 1 to 3 cylinder. The company furnishes the rough castings or machined parts of the motor, as desired, so that it is possible for the buyer to machine and assemble his own engine and thus obtain an engine for the price of the castings.

LIBERTY TUBE CLEANERS of the heavy duty, standard, pneumatic and Niagara types, the Twin strainer, Liberty oil purifier and the Faber blow-off valve are described in a set of bulletins just received from the Liberty Mfg. Co., of Pittsburg, Pa. Special attention is given to the pneumatic cleaner which is to be preferred over the surface cleaner, wherever there is a suitable air supply. In the back of the catalog is a very complete price-list of repair parts of the tube cleaners. The various types of heads are drawn in section and the name of each part indicated, so that by comparing the cuts of the parts with an actual machine, it is an easy matter to identify the type and also to ascertain the name of any repair part needed.

THERE IS NOTHING NEW—NOT EVEN IN FANS, is the title of Bulletin 153 of the B. F. Sturtevant Co.'s Engineering Series. The bulletin gives a resume of Sturtevant fans of half a century ago up to the latest development.

THE D. T. WILLIAMS VALVE CO., of Cincinnati, Ohio, is issuing a new and most complete catalog, comprising a greater variety of specialties than was ever listed by the company before. Increased facilities for turning out high grade steam appliances enable the company to maintain the high standard of its products. The new plant where Williams specialties are made has a manufacturing space of over 75,000 square feet, and is fitted with the most approved appliances for the manufacture of brass and

iron valves, gage cocks, fittings, boiler feed cups, lubricators, separators, steam traps, etc.

OPERATION AND CONSTRUCTION of the Copes boiler feed regulator and the Copes pump governor are thoroughly explained and illustrated in a 12-page folder sent out by the company, upon application.

BULLETINS NOS. 95, 97, 98, 99 and 100 are just at hand from the Crocker-Wheeler Co., of Ampere, N. J. In their order these bulletins describe the company's belt type alternating-current generators, direct-current switchboard panels, Form L direct-current belt type motors and generators, Crocker-Wheeler motors in the Bethlehem rail and structural mills, and Form I machines, which are of the direct-current belt type and in motors are made from 5 to 45 h. p., in generators from 4½to 40 kw.

THE BRUCE-MERRIAM-ABBOTT CO., of Cleveland, Ohio, is now furnishing complete producer gas power plants, consisting of B. M. A. gas engines and suction gas producers, and an independent gas or gasoline starting engine for starting the producer and compressing air for starting the engine. These outfits are designed for general power, electric and pumping service, and are described in Catalog A, 1908 edition, Section I, just issued by the company.

SAWYER BELTING CO., of Cleveland, Ohio, is sending out a most convenient and useful novelty in the shape of an auto-calculator for belt pulleys and a pocket lumber scale. The belt and pulley side is arranged to give the speed of any diameter of pulley, also the speed of belts and the horsepower of the belt for any width and different ply. In the lumber scale, if the section and length is known, the contents in feet of each piece may be read off directly.

SPRAGUE ELECTRIC CO., of New York City, is sending out Circular No. 428, descriptive of its cast steel outlet boxes and fittings, and instruction book No. 226 on the company's Round Type motors and generators. The booklet is devoted to the installation and care of this type of machine.

WRIGHT STEAM SPECIALTIES, Catalog No. 11, has just been issued by the Wright Mfg. Co., of Detroit. These specialties are described as of the "Wright" quality, and certainly the catalog is right; it is beautiful as a work of printing art and full of instructive information. The specialties described include safety alarm water columns, re-grinding gage cocks, high and low-pressure steam traps, exhaust heads, filters and separating tanks. The book is well worth having.

EDISON GEM high efficiency incandescent units are described in Bulletin No. 4561, issued by the General Electric Co., Schenectady, N. Y. The publication is an interesting 16-page pamphlet on illumination, and the best solutions of many of the problems involved, and contains a large number of cuts of the Gem lamp and fixtures especially suited for its installation, etc. Illumination tables giving the foot-candle values on different horizontal planes when the lamp is used with various types of Holophanes are also given. The Gem unit is easily renewed, fits the standard socket and burns on any standard circuit. It gives a perfect distribution of light with a downward efficiency of from 1¾ to nearly 1 watt per candle, and the quality of light is brilliant, soft and uniform, making it especially useful for all interior lighting.

G. I. Flame Arc Lamps are described in a 4-page folder. This lamp is a simple and efficient American development of the flame arc principle using gravity feed without clock mechanism, and is suitable for any standard make of flame lamp carbons.

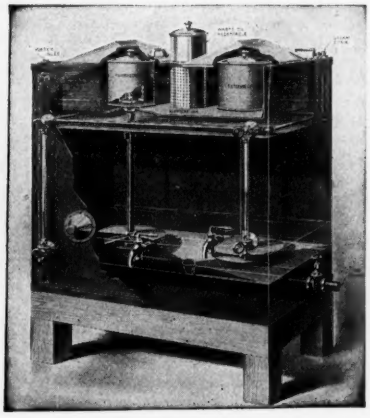
THE BARTLETT WATER SOFTENER is fully described in a handsome catalog just issued by the Northern Water Softener Co., Madison, Wis. Sales agents for this apparatus are the Underfeed Stoker Co. of America, with offices in Chicago. This device is for taking out the scale-forming materials from water for use in steam boilers, laundries, textile mills, tanneries and elsewhere. It operates by treating the water with chemicals which react on the solids in solution, making insoluble substances which are allowed to settle out of the water in the treating tank. The catalog is a fine piece of printing, with 20 pages, and gives full information in regard to the method of treating water, the apparatus used and the chemicals needed.

M. T. DAVIDSON CO., New York City, in its new catalog recently issued, which describes pumps, pumping engines, condensers, separators and evaporators and ash ejectors, has given much useful information in regard to various types of steam pumps in the work to which they are adapted. The general features of pumps are taken up as well as the special features of the Davidson pumps of various types, and a full list of capacities, dimensions and details are included. One of the new types is the Davidson Vertical twin cylinder air pump, which may be worked with either one or two steam cylinders, as desired. The yokes for the pump rods are joined by a walking beam, which makes the action of both pump cylinders positive. The book has 96 pages of text and illustrations, the last 25 pages being devoted to useful tables in regard to pumps and hydraulics.

TWO INTERESTING BOOKS come from the Murray Iron Works, Burlington, Iowa. One of these is an extremely handsome catalog on Safety water-tube boilers, with an embossed cover printed on a gray linen finish paper and with three-tone lithographed illustrations. This gives fully the construction and details of the Murray water-tube boiler, which is mild steel, with large front and back headers and longitudinal drums, the headers being arranged to have handholes opposite the tube ends and hollow staybolts between the handholes. The second book is entitled Nomenclature of Murray Corliss Engines, and gives the different types of engines, with name of each part clearly indicated. It shows also some of the details of the Murray design. The boiler catalog is No. 60 and the nomenclature catalog, Series D No. 7.

MECHANICAL DRAFT is always a subject of interest to engineers. In Bulletin No. 708 the Green Fuel Economizer Co., of Matteawan, N. Y., treats of the apparatus used for such systems and the various systems installed and the use of economizers in this connection, and gives illustrations of the Green apparatus.

BULLETIN NO. 331, issued by the United States Geological Survey, gives the results of tests made on Portland cement mortars at the testing laboratory, St. Louis, 1905 to 1907. This is a book of 140 pages, and tells of experiments made on mortars made with different qualities of cement, testing the mortars for tensile strength, transverse strength and for increase of strength, with time of setting, and covering mortars made out of river sand, gravel and stone screenings. The series consisted of approximately 35,000 tests, and the bulletin gives the results obtained.



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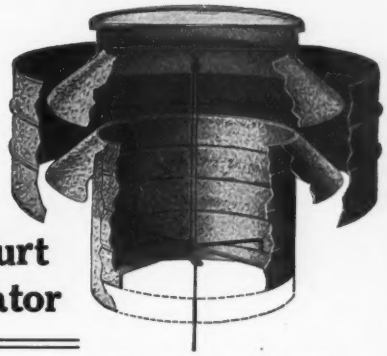

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brings daylight and pure air to the engine room. It will remove hot air, smoke, steam, etc. without lowering the temperature too far for comfort. Our sliding sleeve damper has no flat surface to collect dust and refuse, it always remains in one position, unaffected by air currents, and when closed does not affect the passage of light.

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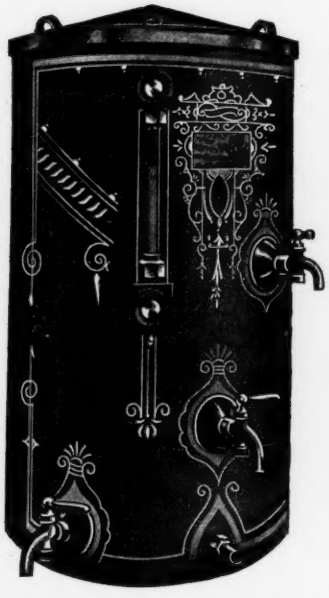

because it removes dirt and grit from your lubricating oil by straining it through waste, then washing it in pure, warm water. Requires practically no attention after starting, nor any great expense to maintain it—just a few cents per year for waste. Has nothing to break or get out of order and cannot clog.

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CATALOG NO. 107 on Asbestos Wood is the latest issue from the press of H. W. Johns-Manville Co., of New York City. This wood is used for building construction and electrical insulation as the fireproof substitute for wood, slate, marble and fiber.

JAMES COYNE, 121 Haverhill St., Boston, is sending out a booklet descriptive of the State Steam Engineering School, established some 12 yr. ago by Mr. Coyne, for the purpose of assisting the engineers and firemen of the state of Massachusetts to comply with the requirements of the license law. Mr. Coyne has had some 25 yr. experience as an actual erecting and running engineer and as a consequence has been very successful in assisting his pupils to satisfy the examiner.

TRADE NOTES

BUCKEYE BOILER SKIMMER CO., Toledo, Ohio, received the following letter from Kellogg & Buck, Morenci, Mich.: "We cleaned our boiler this morning and found that it was in fine shape after giving the skimmer a thorough trial and accordingly enclose our check for the same. We did not care to remit before because we wanted to see for ourselves just what the skimmer would do. It has done just what you claimed it would and we are glad to pay for it promptly."

NO LESS THAN TEN MACHINES, aggregating 25,000 h. p., are included in a large shipment of Westinghouse turbo-electric power equipment from East Pittsburg to the far East. Most of these machines will go to Japan for the equipment of railway, lighting and manufacturing plants. One of the first machines to be put in service will be a 1500 kw. turbine unit for Manila, to be installed in a station with four other machines of like construction, put into service several years ago. Hardly second in importance is the large turbine station of the Osaka Electric Company, Osaka, Japan, now building. This will be one of the largest power stations in Japanese territory and will contain for the present, 15000 kw. in 5 units. Three of these machines are now being shipped from East Pittsburg. The remainder will follow as fast as they can be built and tested. In the strictly manufacturing field, there are two installations in process of creation, for the Imperial Steel Works of the Japanese government and the ship yards of the Hakkaido Tanko Steam Ship Co. Two 500 kw. Westinghouse-Parsons turbo units will comprise an initial installation in each of these plants.

AMONG RECENT ORDERS taken by the Ohio Blower Co., Cleveland, Ohio, for their gravity closing ventilators, is one from the Richardson Paper Co., Lockland, Ohio, for a total of 39 ventilators. Twenty-six of these are 24 in. diameter, for ventilating the machine room; 6 are 36 in. diameter, for ventilating the beater room; and 7 of the same size are to be used for the ventilation of the new power house. All are to be supplied with dampers.

THE BUSINESS of The Curtis & Curtis Co., of Bridgeport, Conn., manufacturers of the Forbes Patent Die Stock, continues to show encouraging signs of improvement. Unusually large shipments have recently been sent from the works on export delivery which includes 6 machines to Russia, 5 to Australia, 5 to England, 4 to Kobe, Japan, 4 to Yokohama, Japan, 3 to Mexico and several to South America and British Columbia. This, with a fair domestic business is very gratifying to the company.

YORK MFG. CO., York, Pa., reports the following list of recent sales: New Seneca Hotel, Rochester, N. Y., 30-ton refrigerating plant; Pacific Fruit Express Co., Colton, Cal., one complete 200-ton ice making plant; Pacific Fruit Express Co., Roseville, Cal., one complete 200-ton ice making plant; Pacific Fruit Express Co., Las Vegas, Nev., one complete 100-ton ice making plant; University of Iowa, Iowa City, Iowa, one 3-ton refrigerating plant; Westerberg & Williams, New York City, N. Y., one 65-ton refrigerating plant for Boston Floating Hospital; Ward Mackey Co., Pittsburg, Pa., one 30-ton compression side and direct expansion piping; American Ice Co., Oxford, Me., one complete 10-ton ice making plant; Brookville Brewing Co., Brookville, Pa., one 30-ton compression side and piping for brewery; Schneible Co., Chicago, Ill., one 30-ton compression side and direct expansion piping for Chicago Heights Brewery; Eastman Kodak Co., Rochester, N. Y., two 400-ton compression sides; City Ice & Cold Storage Co., Seattle, Wash, one 30-ton and one 10-ton refrigerating compression side with 20-ton freezing and distilling system and piping for cold storage rooms.

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PATENTS

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PATENTS

C. L. Parker, Late Examiner, U. S. Patent Office, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 Dietz Bldg. Washington, D. C. 4 tf

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